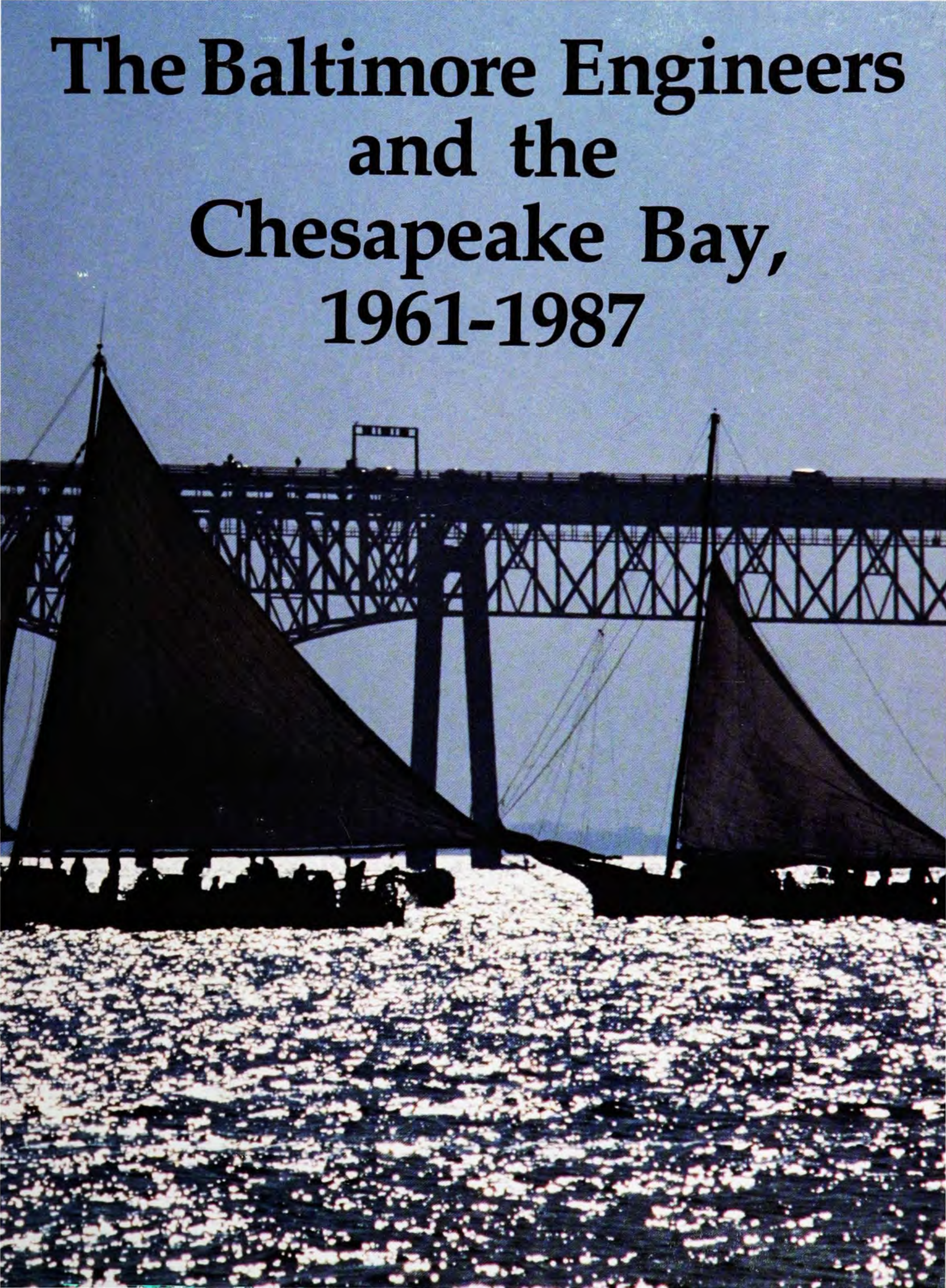
The Baltimore Engineers and the Chesapeake Bay, 1961-1987



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The Baltimore Engineers and the Chesapeake Bay, 1961-1987

By

Joseph L. Arnold

Baltimore District
U.S. Army Corps of Engineers
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Preface

The Chesapeake Bay is a remarkably delicate and complex body of water. Any change in its environment, whether from natural or man-made forces, is likely to have wide consequences. For a long time natural forces were the overwhelming factors in determining the abundance of its aquatic life; but in the 20th century, man has become the greatest threat. Hardly a week goes by without the appearance of a story detailing yet another abuse of the Bay. Sewage, fertilizers, toxic chemicals, sediments, acid rain and numerous other problems have received attention. Today, however, the newspapers also carry many articles on the large-scale struggle to save the Bay. This book examines a small but highly significant part of that important effort.

Like the great estuary itself, the administrative machinery and political decision-making underlying the restoration of the Chesapeake are very complex. Dozens of federal agencies operate in the Bay area, three state governments and the District of Columbia play an important role, and a host of county and local governments are involved along with a wide variety of private interests—businesses, trade associations, yacht clubs, property owner associations and citizen environmental groups. Amidst this array of public and private institutions is the Baltimore District of the U.S. Army Corps of Engineers, headquartered in Baltimore, Maryland. The Baltimore District encompasses the great majority of the Bay and its tributary rivers. Only a relatively small portion of the lower Bay lies outside its jurisdiction. The Corps of Engineers is only one of many agencies sharing responsibility for the Bay area, and its activities are closely coordinated with other agencies. Nevertheless, its role as a separate entity is extensive and important. For example, it is responsible for gigantic construction projects such as the Baltimore navigation channel and it also exercises authority over each small change that an individual or institution wishes to make along the Bay shoreline or adjacent wetlands. In addition, the Corps has extensive responsibilities and authority over the hundreds of rivers and streams that feed the Bay.

In sum, the Baltimore District plays a major role in determining the manner in which human activity affects the Bay. Like many other Bay-area institutions, the Corps has, in the past, made mistakes that injured the Bay environment; but it has learned from these mistakes and has responded forcefully to the new environmental legislation which allows it to become much more protective of the Bay's aquatic life. The Corps is now an enthusiastic participant in the inter-governmental Chesapeake Bay Program.

This book was written because the Corps felt that neither the general public nor even those with a special interest in the Chesapeake have been fully aware of the many areas in which the Baltimore District has been active around the Bay during the past thirty years. I hope that my review of the district's Bay-related programs and policies will give readers some historical perspective to the agency's current efforts to carry out the laws of the federal and state governments pertaining to the Bay. These laws have been dramatically revised and expanded over the preceding three decades. While it is difficult to characterize this body of legislation in a single statement, its fundamental goal appears to be an attempt to strike a general balance between allowing the Bay to be used and even altered by the public, but not in ways that destroy the environmental qualities for which it is so valued.

As an agency of the federal government, the Baltimore District is responsible for finding the specific points of balance between these two often conflicting legislative goals as it translates broad principles of law into specific decisions. It is my hope that the study of the role of one particular government agency in the Chesapeake Bay will also provide some insight into the total inter-governmental effort to restore and preserve this great national resource.

In conducting this study I received valuable help from a large number of people and wish to acknowledge the following individuals for their generous assistance. At the Baltimore District of the Corps of Engineers: Noel E. Beegle, Robert N. Blama, Harold K. Clingerman, Henry G. Dunn, H. Glenn Earhart, Thomas J. Filip III, Charles M. Franklin, Harold K. Kanarek, Larry J. Lower, Jeffrey A. McKee, Steven W. Merrill, Harold L. Nelson, Donald W. Roeseke, Major Joel M. Sauer, Denise E. Tann, Charles E. Walker, Colonel Martin W. Walsh, Jr., and Beverly O. Wooldridge. At the

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Chapter I
The Corps, the Bay, and the Chesapeake Bay Program

The Chesapeake Bay is a unique and magnificent body of water that is in serious ecological danger. For many years, Bay watermen watched their catches of oysters, crabs, rockfish and other species decline alarmingly. Scientists in government agencies and universities recorded dangerous levels of pollutants, suspended sediments, and nutrients in Bay waters. Citizens who went boating on the Bay noticed the dramatic losses of submerged aquatic vegetation—one of the key links in the Bay's complex and delicate food chain. In the early 1960s it was not known to what degree all these developments were interrelated, but it did not require a degree in marine biology to guess that human activities in the Bay and its watershed were a major factor.

In areas where shipping channels had been dredged, the impact of human activity was quite evident. The long history of overboard disposal of dredged materials had periodically stirred up millions of tons of sediments and significantly altered many acres of the Bay's floor adjacent to the channels. No one knew what the specific or cumulative effects of all this activity was on the Bay, but by the early 1960s a number of groups, including the Corps of Engineers, began to worry about it.

The shores of the Bay also changed in ways that troubled many observers. Mile after mile of shoreline was being locked behind bulkheads and thousands of acres of marshlands filled in behind them, with no thought of the specific impact on local waters or of the cumulative effect. As man worked to fill in the Bay shorelines, natural forces sought to wash it away. At many locations shoreline erosion was eating rapidly away at people's shorefront properties.

It appeared that many of the Bay's problems, particularly the losses of marine life and aquatic plants, started along its tributary rivers and streams. As early as 1961, the Corps was one of several agencies, state and federal, to express "grave concern" over the threat of polluted rivers to the future of aquatic life in the Chesapeake.[1] Nutrients coming down the Susquehanna from sewage treatment plants and generously fertilized croplands was suspected by some to cause giant algae blooms in the upper Bay as well as a lack of oxygen in the deep waters of the mid-Bay area—conditions that seemed related to the steady decline of many fish populations. Further down the Bay on the Potomac River, the very rapid growth of the Washington, DC area increased the amount of sewage and non-point pollution flowing into the Potomac estuary while at the same time withdrawing more water from the river for human consumption.[2]

It seemed evident that the problems on the Susquehanna, Potomac and the other rivers of the Chesapeake watershed were altering the entire Bay, but exactly how and why was not well understood or documented. The first large scale study of water pollution in the Bay was finally begun in 1963 by the U.S. Public Health Service. The Environmental Protection Agency expanded the study in 1976 and published the results in 1983. Many Bay-area residents did not wait for the completion of these long-term studies. By the late 1960s a number of them came to believe that the Bay was in serious trouble. In 1968 the state of Maryland sponsored a high-level conference on the Chesapeake to alert officials and political leaders to the danger. At the same time the Baltimore *Sun* published a major series of articles entitled "The Chesapeake at Bay" which contained uniformily gloomy assessments of the estuary's future from a wide spectrum of scientific experts and government officials.[3] Citizen's groups were formed to study the problem and gather public support for a Bay-wide rescue effort. Soon bumper stickers began to appear that said simply, "SAVE THE BAY."

Eventually, the Chesapeake region and the federal government responded to the alarm bells sounded in the 1960s. A number of state, federal and private agencies were given funds to study the Bay's problems. In 1983 and 1984 the two largest of these studies were completed and made available to the public. The Baltimore District of the Corps of Engineers published the final results of their seventeen-year Chesapeake Bay Study in 1984. It detailed existing and future pressures on the estuary and its rivers by the area's huge and growing population and made a number of important recommendations aimed at reducing the adverse impacts of these pressures on the aquatic environment. The

Corps' recommendations, which will be discussed in Chapter III, embodied a series of specific programs in the areas of tidal flooding, water supply and drought management, dredged material disposal, and the dynamics of Bay salinity levels as it relates to freshwater inflows.[4] These programs would be carried out jointly by federal, state and local agencies. A few months earlier, the Environmental Protection Agency had issued the final report on its seven-year study of water quality in the Chesapeake and its impact on the Bay's living resources. This landmark report documented in detail the alarming deterioration of the Bay's ecosystem that resulted from an overloading of nutrients, toxic compounds, heavy metals and sediments in its waters. It also recommended a joint federal-state program to restore and protect water quality in the Bay. In December 1983, Maryland, Virginia, Pennsylvania, and the District of Columbia, and the U.S. Environmental Protection Agency signed the Chesapeake Bay Agreement pledging to work together to halt the decline of the Bay's living resources. A month later President Reagan, in his State of the Union Message, pledged the support of the federal government to help clean up the Chesapeake—a body of water he referred to as "a special national resource."[5]

The Chesapeake Bay Agreement resulted in the establishment of a Chesapeake Bay Program (CBP) with an Executive Council, a staff and supporting committees. Shortly thereafter, in 1984, the program was expanded to include other major federal agencies active in the Bay: the Corps of Engineers, U.S. Fish and Wildlife Service, Soil Conservation Service, National Oceanic and Atmospheric Administration and the U.S. Geologic Survey. Leading officials from these agencies met in October 1985 with the heads of all the state-level agencies involved with the Bay in a two-day "Chesapeake Bay Forum" held by the Corps of Engineers at Fort McNair in Washington, DC. Strategies for restoring and protecting the Bay were discussed by the Chief Administrators of the Corps, EPA, Fish and Wildlife, the heads of the environmental resource departments of the three Bay-area states, and officials from the new Chesapeake Bay Commission.[6] The Executive Council of the Chesapeake Bay Commission promulgated a plan in 1985 for the first phase of the Bay restoration and protection program. Reflecting the broadened scope of the CBP since the entrance of the Corps and the other federal agencies, the council's plan included a broad range of restoration and protection goals in addition to pollution abatement. It also committed the CBP to a continuing research and experiment effort to fill in the numerous gaps in knowledge that hinder the development of an effective management program for the Bay. In December 1987 the governors of the three Bay states, the Mayor of Washington, DC and federal officials signed an agreement setting specific goals and timetables for reducing pollution in the Bay.[7]

Since 1983, state, federal, and other agencies, working cooperatively through the Chesapeake Bay Program, have spent several million dollars each year on research and monitoring in the Bay and its watershed. During that same period over $400 million has been spent by the Bay states and federal agencies to reduce pollution from specific points such as sewage plants and non-point pollution—chiefly the nitrogen-rich runoff from farm lands. Most of the funds have been expended to improve wastewater treatment facilties.[8] Joint state-federal efforts are also moving forward to ensure that those who wish to use or alter any part

A satellite photo of the unique and magnificent Chesapeake Bay shows no serious ecological danger. But watermen watched their catches decline. Scientists recorded dangerous levels of pollutants, suspended sediments and nutrients. Boaters noticed dramatic losses of submerged aquatic vegetation.

of the Bay and its tributaries will do so in an environmentally sound manner. In other words, they are working toward the development of a Bay management plan.

This is a complex and expensive task. The Bay and its watershed cover 68,470 square miles used by millions of people each year. Public funds for the restoration and protection of the Bay have grown substantially since the 1960s, but will have to compete in the future with other important public programs. Limited funding means research and management of the Bay environment will have to be very cost-effective.[9] For this reason the continued restoration and protection of the Bay calls for all the knowledge and ingenuity that can be mustered by the Bay community.

The U.S. Army Corps of Engineers, and the Baltimore District in particular, has been a significant member of this Chesapeake Bay community since the early 19th century. It began to play a major role in the restoration and protection of the estuary during the 1970s and now occupies a key position in the Chesapeake Bay Program.

To some it might appear anomalous that an agency composed of military engineers could occupy such a central role in what is primarily an environmental issue. The answer is that congressional legislation and executive orders have transformed the environmental policies of the Corps of Engineers since the coming of the environmental movement in the 1960s. The Baltimore District is now a major center of environmental knowledge and responsibility for the Chesapeake Bay. In this role, the district is supported by an equally knowledgeable and committed group of military and civilian officials in the Office of the Chief of Engineers, the Corps' Waterways Experiment Station, and other components of the nationwide agency. Exactly how this remarkable change has occurred during the last two decades requires some explanation.

Prior to the 1960s, the Corps, like most other public and private institutions, showed relatively little interest in environmental protection. But with the coming of the national environmental awareness movement in the 1960s, the federal government and many of its agencies, the Corps of Engineers among them, began to recognize the profound and long-term affects of environmental neglect. Congress heard the message and passed the Clean Air Act of 1963, the Water Quality Act of 1965, and the National Environmental Policy Act of 1969 (NEPA).[10] In 1970 President Nixon created, by executive order, the U.S. Environmental Protection Agency. During the 1970s a number of significant amendments to these basic pieces of legislation strengthened environmental regulations and increased the ability of federal agencies to carry out programs to protect and enhance the environment. The Corps and the Baltimore District have been particularly affected by federal court decisions in the 1960s reinterpreting Section 10 of the 1899 River and Harbor Act and the passage of Section 404 of the Federal Clean Water Act of 1972, requiring all persons seeking to dispose of dredged or fill material in the nation's waterways to obtain a permit from the Corps of Engineers. Disposal of dredged or fill material was no longer allowed if it presented an unacceptable adverse effect on municipal water supplies, shellfish, and fishery areas or recreational activities.[11]

The Corps of Engineers was deeply affected by the legislation of the 1970s, but in several areas it had begun to move toward a position of greater environ-

mental responsibility before NEPA was passed. For example, since 1958 the Corps has cooperated with the Fish and Wildlife Service and the National Marine Fisheries Service to protect fish and wildlife resources, providing mitigation for damages to these resources in the course of building flood control and navigation projects.[12] In 1962 the Corps helped draft the President's Water Resources Council statement on the planning of water resources projects. Also, the Chief of Engineers established in 1969 the Institute for Water Resources to conduct and oversee "research in all phases of water resources planning to evaluate existing methods, procedures, and criteria, and to develop new and innovative techniques, giving particular attention to environmental quality, regional development, and interregional and international planning."[13] Between 1966 and 1969 the Corps issued over 20 regulations requiring increased attention to environmental and aesthetic values in project planning. Even more important, it began to hire a substantial number of professionals in landscape architecture, biology, forestry, agronomy, and other environmentally-related fields to help plan its construction projects, and participate in its regulatory activities. By the time NEPA was passed in 1969, the Corps had hired 287 such individuals. No longer was the Corps of Engineers an agency composed exclusively of engineers.[14]

Even with these changes before 1969, the Corps was deeply affected by the National Environmental Policy Act of 1969, the Federal Water Pollution Control Act Amendments of 1972, and by two Supreme Court decisions in 1966 and 1975. NEPA is a major landmark for the Corps of Engineers, as it was for all federal agencies involved in construction projects or regulatory decisions having an impact on the environment. The law required that all federal agencies submit an Environmental Impact Statement (EIS) with every report that recommended actions affecting the environment.

In response to NEPA the Corps established an Environmental Advisory Board in 1970 to provide guidance on a host of environmentally related issues. The board was composed of distinguished scientists, planners, and environmentalists. Lieutenant General Frederick J. Clarke, the Chief of Engineers who established the advisory board, did so with full knowledge that a number of Corps officials were not entirely sympathetic to the new environmental movement.[15] One official told Clarke, "I didn't join the Corps of Engineers to come up with non-structural solutions." Clarke later said that some people thought he was crazy "sort of letting the enemy into the camp."[16] However, the advisory board proved to be

a substantial help to the Corps in developing sound environmental planning procedures to implement the provisions of NEPA and subsequent environmental legislation. A study of the Corps response to the environmental reform movement between 1970 and 1977 by the Brookings Institution concluded that it made a "serious and honest effort to cope with environmental considerations in reorganizing its structure."[17]

In certain respects the Baltimore District had a head start on the environmental movement prior to NEPA. The Susquehanna and Potomac River Basin studies, chaired and coordinated by the Baltimore District, were inter-disciplinary, inter-agency studies which assessed a wide range of issues that included environmental restoration and protection. The Potomac River

Children enjoy the benefits of cooperation between the Corps of Engineers, the Fish and Wildlife Service and the National Marine Fisheries Service to protect fish and wildlife. The Corps provides mitigation for damages to resources in the course of building flood control and navigation projects.

Basin Study, which was conducted between 1956 and 1963, examined environmental issues such as water quality, outdoor recreation needs, conservation of fish and wildlife, low-flow augmentation, and soil erosion, although its major recommendations dealt with flood control and water supply.[18]

Most of the conservation and environmental aspects of the Potomac River Basin Study were conducted for the Baltimore District by other agencies. At that time the Baltimore District had almost no people trained specifically in these areas, and the Chief of Engineers Office had very few such people on which the district could draw for advice. The Susquehanna River Basin Study began in 1963 just as the environmental movement was making itself felt in Congress and the nation. In particular, the publication of Senate Document 97 in 1962 caused the Susquehanna River Basin Study Coordinating Committee, which was chaired by the Baltimore District Engineer, to make what he called a "significant mid-course correction in the conduct of the Susquehanna Study" to make environmental quality co-equal with the original goals of economic efficiency and regional economic development.[19] The study was completed in 1969, just as NEPA was enacted. The Potomac and Susquehanna studies provided useful analyses of water resource needs and problems in the Chesapeake Bay's two largest sources of fresh water, providing important data which was later used in the Chesapeake Bay Study. Equally important, they gave the Baltimore District valuable experience in interdisciplinary investigations and in the coordination of research among

many different agencies and institutions.

One of the major factors hampering efforts of the Baltimore District to conduct interdisciplinary studies of river basins was the lack of trained biologists, chemists, land use planners and other such scientists who could evaluate environmental issues and plans.[20] The passage of NEPA solved this problem by requiring environmental impact statements on every major Corps action, a task that required the hiring of people with this training, and the additional training of existing staff members. The Baltimore District established an Environmental Analysis Branch (EAB) with three people, a land use planner, a biologist and a chemist. This eventually grew to a staff of 11 professionals plus support positions. For its first few years, the branch was part of the Engineering Division, but in the mid 1970s a separate Planning Division was created with the Environmental Analysis Branch operating as a key adviser on all planning projects. The branch is the major center of environmental expertise for the Baltimore District and its staff participates in every activity that touches on environmental issues. It conducts the studies needed to plan and execute specific projects. Most of this research is contracted out to universities and private environmental research firms. This is done because it is more cost-effective for the Corps' environmental experts to design the project-specific research programs and have others collect the data.

In addition to the Planning Division's EAB, the district's Regulatory Branch has become a second major center of environmental expertise. The Corps has exercised authority over all alterations of the nation's navigable waterways since the passage of Section 10 of the River and Harbor Act of 1899, but it chose a very narrow and restrictive interpretation of its authority. A 1966 Supreme Court decision interpreting the meaning of the 1899 Act gave the Corps a clear mandate to control water pollution in navigable waterways, presenting the Corps with a large new area of regulatory responsibility. The Federal Water Pollution Control Act Amendments of 1972 transferred some of these responsibilities to the EPA, but Section 404 confirmed the 1966 court decision. A 1975 decision by the Court of Appeals of the District of Columbia extended this responsibility to all adjacent wetlands as well. Each year, the Baltimore District's Regulatory Branch makes decisions on permit applications involving hundreds of millions of dollars. The branch is staffed by a group of chemists, biologists and ecologists who investigate all applications for dredge and fill permits to determine if they are in compliance with the letter and spirit of NEPA. This group of regulatory experts is also called upon consistently by the other branches and divisions of the district, to offer advice and to help solve planning problems because of their knowledge in the areas of aquatic ecology and wetland environments.

The Operations and Planning divisions have also added personnel trained in the life sciences or land use planning, often in addition to their training as engineers. In this way the district has, over the past 19 years, become a major center of expert knowledge on the environment of the Chesapeake Bay watershed. For example, Larry Lower, the chief of the Environmental Analysis Branch of the Planning Division, came to the district in 1969 as one of the pioneer members of the environmental branch. Donald Roeseke, a civil engineer and chief of the regulatory program, has been with the Baltimore District since 1961 and the assistant chief is Tom Filip, a chemist, who came in 1974. Noel Beegle, originally trained as a civil engineer, played a central role in the Chesapeake Bay Study and is now chief of the Chesapeake Bay and Special Studies Branch and an authority on the Chesapeake Bay. Glenn Earhart, a biologist in the Navigation Branch is an expert on dredging, but is more widely known as the planner of several of the most promising artificially created fish and wildlife habitats in the Chesapeake Bay.

This book explains how the Baltimore District, with its increased knowledge and concern for environmental protection, has responded to the challenging task of restoring the Chesapeake Bay and its tributary rivers. In several ways the Baltimore District offers one of the best vantage points from which to view the modern history of the Bay. The district has been active in and around the Chesapeake longer than any other federal agency. Its construction projects and regulatory functions affect the bay's ecological system at many critical points, and its statutory responsibilities encompass the widest range of goals given to any Bay-related federal agency.

While many federal agencies have important responsibilities in the Bay, these functions tend to fall in the same general area of endeavor and are easily compatible with one another. For example, the U.S. Fish and Wildlife Service carries out a number of different activities, but most are generally related to its protective function. The National Marine Fisheries Service also has a variety of missions, but its chief mandate is to increase the supply of commercially valuable fish species. Even the Environmental Protection Agency, with its broad and important mandates to study and enforce water and air quality standards, is not compelled by its authorizing legislation to pursue major goals outside the area of environmental protection.

The Corps of Engineers builds the Bay Hydraulic Model after Congress assigned the first major assessment of the Bay's existing and future conditions to the Baltimore District in 1965.

Things are different for the Corps of Engineers. Over the past 150 years Congress has given this agency an unusually wide variety of duties. During the 19th century its coastal defense works protected the Chesapeake against foreign invaders. Its largest task has been the improvement and maintenance of the Bay's navigable waterways. The Baltimore District has been working on this since 1852.[21] This is a major responsibility involving the expenditure of hundreds of millions of dollars. The Chesapeake's major navigation channels carry trade worth billions of dollars and support thousands of jobs in the region—particularly in Baltimore. In 1986, 2,823 vessels moved in and out of the Port of Baltimore, carrying 24.7 million tons of freight valued at $15.5 billion.[22] In addition, the Bay's large commercial fishing and recreation industries, which employ thousands more, could not survive without the more than 120 smaller navigation channels. In order to build and maintain all these waterways, the Baltimore District developed over many decades a detailed knowledge of the Bay's hydrographic characteristics. Congress was aware of this center of expert knowledge within the Corps of Engineers, and this proved to be an important factor in its 1965 decision to assign to the Baltimore District the task of preparing the first major assessment of the Bay's existing and future conditions. To aid in the accomplishment of this task, the Corps' Waterways Experiment Station built for the district a gigantic hydraulic model of the Bay on Kent Island across from Annapolis, Maryland. It was the largest estuarine model in the world. Many tests were run with the Bay hydraulic model that provided data which had previously been impossible to gather.

The Corps has also been working for many decades on the tributaries of the Bay. It has been collecting data on the Potomac River since 1824. It surveyed the route for the Chesapeake and Ohio Canal along the Potomac's northern bank from Washington to Cumberland and built the ship navigation channels below the city. Since the 1850s it has been in charge of supplying water to the nation's capital, and in the 1970s coordinated a comprehensive water supply study and the development of a mathematical computer model for water supply in the entire Potomac basin in order to manage Washington area water supply use. The Corps began navigation improvements on the Patapsco River in 1852 and on Susquehanna in 1858. By the 1860s it was surveying and dredging on the Chester, Choptank, Wicomico, Tred Avon and many other of the Bay's rivers and harbors.[23]

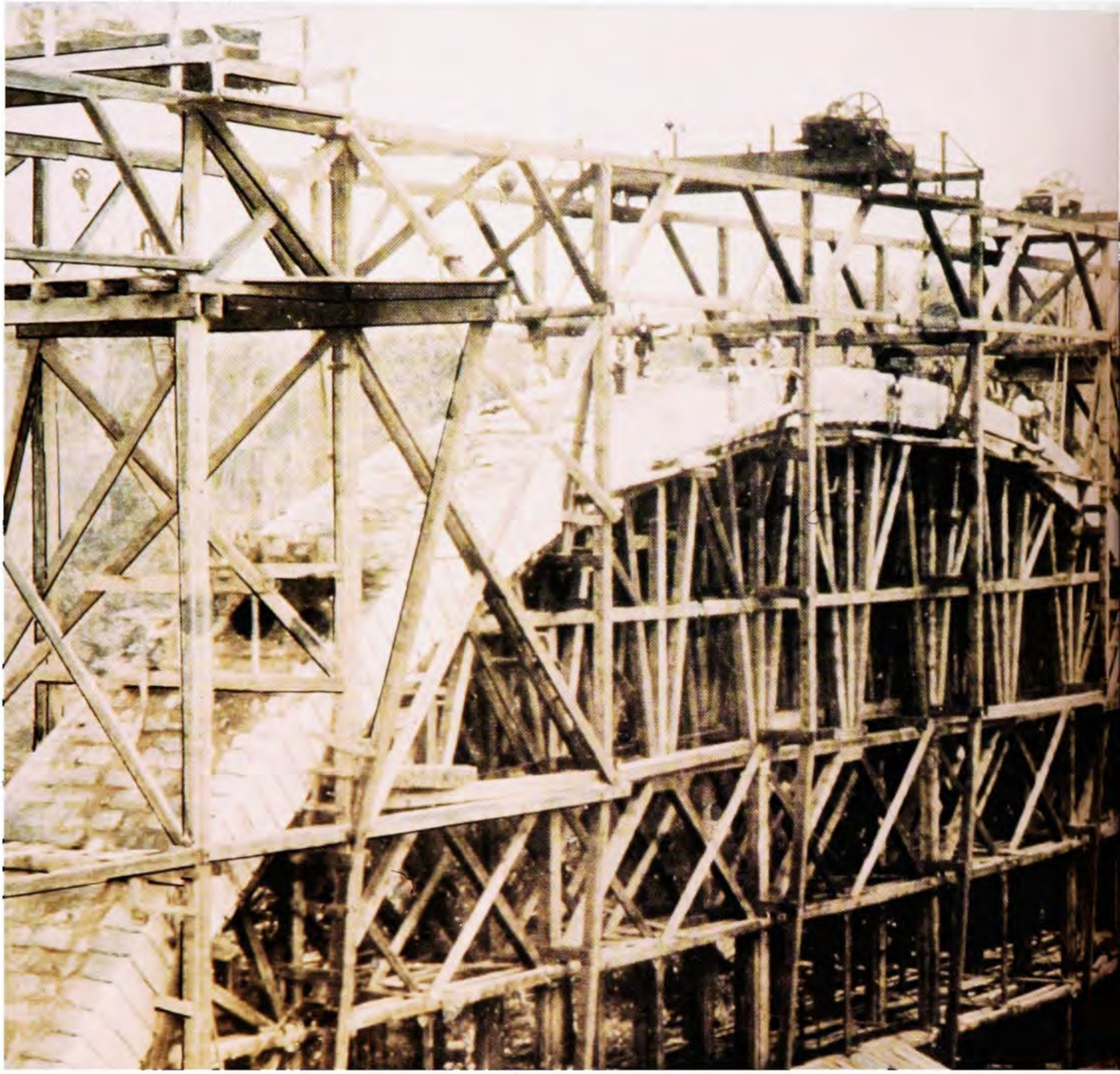
In 1936 Congress gave the Corps the responsibility of controlling floods on the nation's rivers.[24] Both the Susquehanna and Potomac are subject to severe flood-

ing. Over the past 50 years the Baltimore District has constructed and put into operation 15 multi-purpose reservoirs on the headwaters of the Potomac and Susquehanna rivers—streams which together provide the great majority of fresh water for the Bay.

Another important extension of Corps responsibilities in the Bay and its watershed is its increased regulatory authority under the Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977. As explained earlier, the Clean Water Acts and federal court decisions have extended this Corps authority to include the degradation of water quality in all wetlands of the United States. Thus the Baltimore District has the responsibility of assuring that federal water quality standards are maintained for every dredge or fill project in any part of the Bay, its shoreline and adjacent wetlands, its rivers, streams, creeks and their adjacent wetlands.

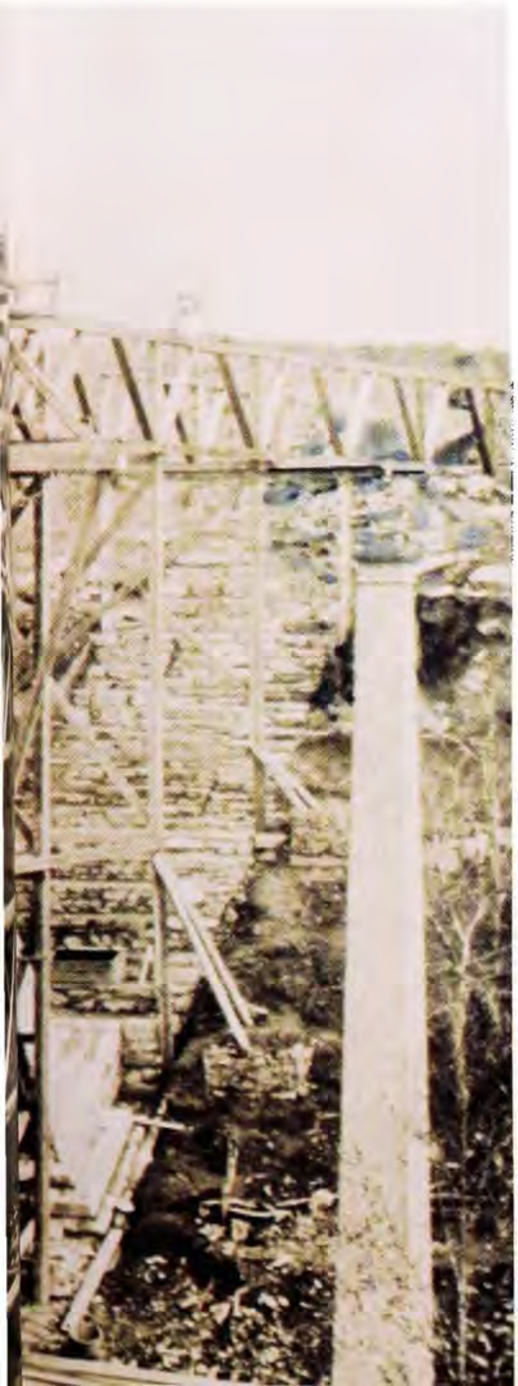
The most recent expansion of the Baltimore District's activities in the Chesapeake Bay has come with its entrance into the joint federal-state Chesapeake Bay Program. It will be recalled that the program was established in December 1983 by the states of Maryland, Pennsylvania and Virginia, the District of

The Corps, charged with supplying water to the nation's capital since the 1850s, crosses Cabin John Creek, where an original conduit of the Washington Aqueduct spans the ravine atop the longest stone masonry arch in the world.



Columbia and the U.S. Environmental Protection Agency. At that time the chief officials of these five entities pledged themselves to achieve the following goals: 1) improve and protect the living resources of the Bay water system, 2) accommodate growth in an environmentally sound manner, 3) assure a continuing process of public input on Bay issues, and 4) support and enhance a regional, cooperative approach toward Bay management.[25]

The Chesapeake Bay Program management structure consists of the Chesapeake Bay Executive Council which oversees and reviews fundamental policy goals, an implementation committee to coordinate achievement of the goals, and a group of subcommittees to handle specific areas such as modeling and research, technical advice, and citizen participation.



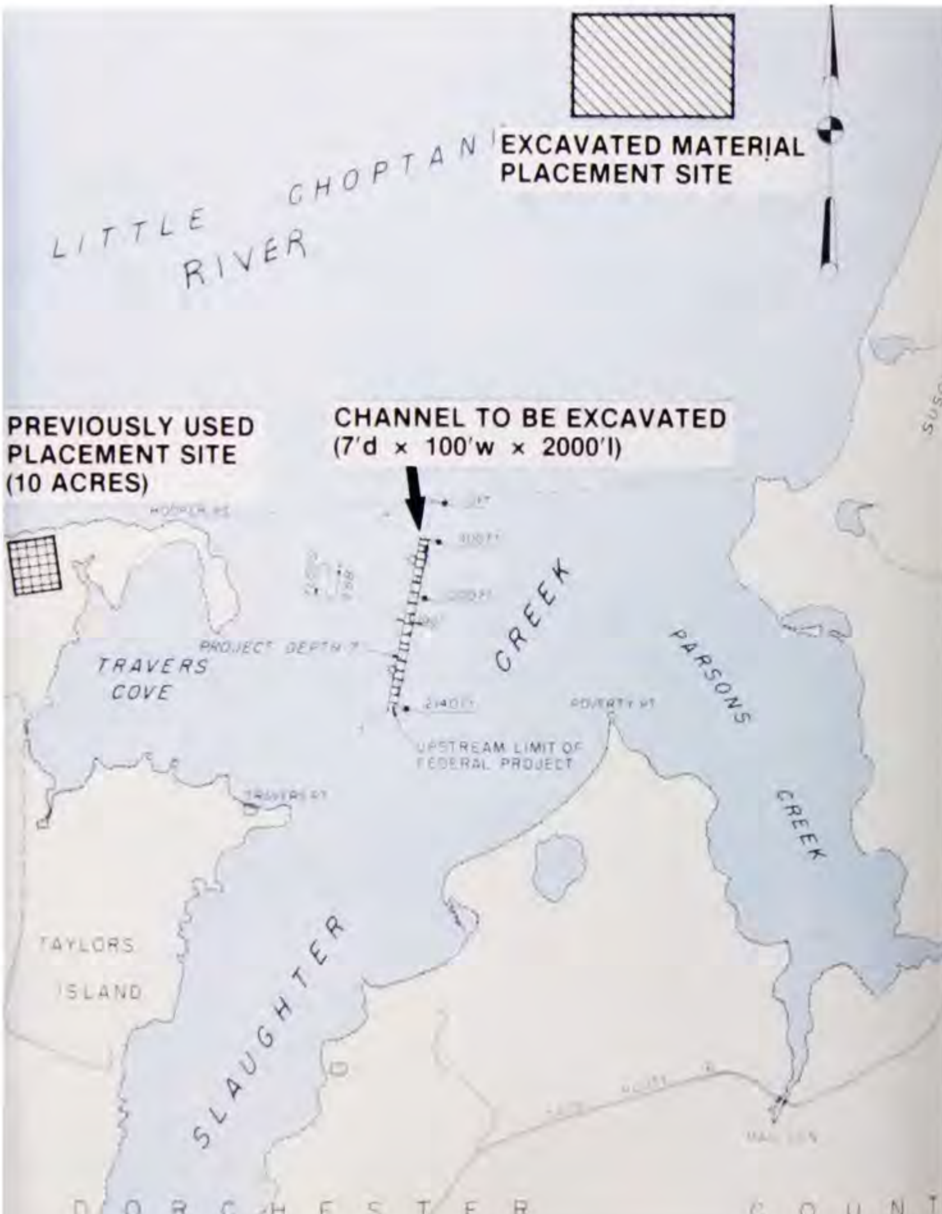
In July 1985 the CBP Executive Council published a document entitled "Chesapeake Bay Restoration and Protection Plan," a series of more specific goals that represent the first phase of the Chesapeake Bay Program. The major features of this plan are: 1) reduction of nutrient loadings in the bay from point and non-point sources, 2) reduction of toxic materials in the Bay, 3) restoration and protection of the living resources of the Bay (fish, wildlife, wetlands, shoreline and riverine systems and freshwater flows), and 4) development and management of Bay-related environmental programs with concern for their impact on the Bay (waste disposal, dredged material disposal, ground water, air quality, recreation facilities, and recreational/commercial fishing).[26]

The Corps of Engineers entered the Bay program in November 1984 through a Memorandum of Understanding (MOU) with the EPA's Chesapeake Bay Liaison Office. At the same time the U.S. Geological Survey, the Soil Conservation Service, the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service also joined the program through similar MOUs. The Corps agreed to sit on the CBP's Implementation Committee and its various subcommittees, provide expert advice and information to the program when needed, and cooperate with CBP monitoring activities.[27] In a separate but

The Baltimore District's dredge and fill permit program is used to protect and enhance the shoreline and wetlands throughout the Maryland portion of the Bay.

related action, the EPA and the Department of Defense (DOD) signed a joint resolution on pollution abatement in the Chesapeake Bay region. The DOD committed itself to improving pollution abatement facilities at the 66 DOD installations in the Chesapeake watershed with the Baltimore District assigned the lead role.[28] The district, therefore, carries the major burden in fulfilling the DOD's commitment to the Chesapeake Bay Program with the Baltimore District Engineer representing the Corps on the CBP Implementation Committee. In July 1985 the District Engineer appointed a Chesapeake Bay Coordinator to oversee Corps activities in the Bay and direct all intergovernmental relations between the district and the other agencies working in the Bay programs.

A number of long established environmental policies and programs of the Baltimore District have been identified by the Chesapeake Bay Executive Council as part of its current Restoration and Protection Plan.[29] The plan calls for an environmentally sound dredged material disposal program, a goal that the Corps and the Baltimore District have been implementing for over a decade. A number of the council's goals listed under the general heading of "Living Resources" have also been pursued by the Baltimore District for a number of years. The goal to restore, enhance, and protect fish and wildlife is an important aspect of several district programs. The dredge and fill permit program under Section 404 of the 1972 Clean Water Act has been intentionally used by the district's Regulatory Branch to protect and enhance shoreline



Experimental beneficial uses of dredged materials provides demonstrations of wildlife habitat such as marsh creation at Slaughter Creek.

and wetland areas throughout the Maryland portion of the Bay. The long record of ecological destruction in this area has been completely halted. The district's program for the beneficial uses of dredged materials has provided important experimental demonstrations of wildlife habitat creation. Now the district is experimenting with the creation of shellfish habitat. The large shoreline erosion study, recommended as part of the district's Chesapeake Bay Study in the 1970s, represents the major effort to meet the council's goal of reducing shoreline erosion and its accompanying sedimentation. The council goal to "maintain freshwater flow regimes necessary to sustain estuarine habitats" has been the subject of a great deal of effort by the district during its Chesapeake Bay Study and is continuing under its current Chesapeake Bay and Tributaries Reallocation Study.

The most important contribution of the Baltimore District and the Corps to the overall management of Chesapeake Bay may well be its role in computer modeling. The February 1987 *Annual Report* of the Chesapeake Executive Council stated:

> Modeling is an essential element of planning for the Chesapeake Bay. It is an essential tool for managers who need to understand the impacts of [pollution] loadings on living resources and water quality. Modeling provides a simplified representation of cause and effect relationships.[30]

Experts in the Baltimore District, supported by the personnel of the Corps' Waterways Experiment Station in Vicksburg, Mississippi, are some of the most experienced physical and numerical modelers in the world. The Chesapeake Bay Hydraulic Model and the Potomac Basin Washington Area Water Supply Mathematical Model, developed jointly by the Baltimore District, the Interstate Commission on the Potomac River Basin and Johns Hopkins University in 1980, have already contributed greatly to the Chesapeake Bay Program. Thus it was quite natural when the Corps formally entered the Chesapeake Bay Program, it would seek to play an important role in numerical modeling. In November 1984 Secretary of the Army, John O. Marsh, Jr., told then EPA Administrator William Ruckelshaus that the Corps was ready and willing to assist with the development of computer-generated models that might be required to help the Bay program meet its environmental goals.[31] Officials from the Baltimore District participated in the discussions of this issue on the CBP's Implementation Committee and the Modeling and Research Subcommittee (MARS). Baltimore District officials, working with the Maryland Office of Environmental Programs, developed a preliminary plan to create a three-dimensional, time varying, hydrodynamic, and water quality model of the Bay. The plan was approved in November 1985. Corps experts in Baltimore, working with those from the Waterways Experiment Station, then developed a detailed plan which was approved by the CBP and Secretary of the Army Marsh in 1986.[32] It is to be a joint venture by the Corps and several other agencies. The Corps will develop the hydrodynamic model at a cost of $1.5 million, and a group of agencies led by EPA will develop the water quality model at a cost of $1.7 million. The hydrodynamic model will drive the water quality model so the two must be compatible. A memorandum of understanding between the Corps and EPA was signed on August 28, 1987 and the project is moving toward completion in 1991 or 1992.[33]

As mentioned earlier, a large and important contribution of the Baltimore District to the Chesapeake Bay Program is the U.S. Department of Defense (DOD) Environmental Restoration and Pollution Abatement Programs in the Chesapeake region, a program in which the Baltimore District plays the leading role. As part of its nation-wide environmental program, the DOD made a special commitment to aid the Chesapeake Bay clean-up. On 13 September 1984 Secretary of Defense Casper Weinberger and EPA Administrator William D. Ruckelshaus signed a joint resolution on pollution abatement in the Chesapeake Bay whereby DOD agreed to give priority consideration to funding pollution abatement projects and studies in the Chesapeake Bay region.[34]

Because of the Bay's proximity to the nation's capital and the Pentagon, the DOD has a very large presence in the region. It maintains over 60 military installations in the Chesapeake Bay watershed encompassing nearly 400,000 acres of land employing over 250,000 people.[35] Many of these installations front directly on the Bay or its tributary rivers—places such as Aberdeen Proving Ground, the U.S. Naval Academy, Fort George G. Meade, and Patuxent Naval Air Station. Most of these facilities are located in Maryland, but there are a number in Pennsylvania and Virginia. The Baltimore District is responsible for 66 military installations and facilities in Maryland, Pennsylvania and northern Virginia. DOD has already spent over $180 million to upgrade or replace pollution abatement facilities at its Bay area installations. For example, in 1983 the Baltimore District, working with the state of Maryland and EPA, completed a $22 million advanced wastewater treatment plan at Fort George G. Meade, one of the DOD's largest installations in the Bay region. The new treatment plant has had a significant impact on water quality in the

Patuxent River, one of the Bay's major tributaries.[36]

The military facilities environmental restoration program in the Bay area has been in operation for over a decade and involves many different departments of the government. For example, one of the recent projects has been the environmental restoration of former NIKE sites in the Bay area. Jack Wilhelm, now a retired mechanical engineer, directed the Baltimore District's phase of this program with the aid of personnel from the Environmental Analysis Branch. They handled about 17 projects a year, conducting a detailed audit of each facility's environmental condition. If restoration of contaminated soil is required, the Corps' Missouri River Division takes the data developed by the Baltimore District and designs the restoration program. If the site is found to contain unexploded ordnance or explosive wastes of any kind, specialists at the Corps' Huntsville Division are often called in to handle this type of problem.

Each study begins with a historical analysis of the records of the facility to see what activities occurred at the site and what environmental hazards might be expected. On-site inspections and tests are conducted next, followed by a decision whether or not to recommend further action. Some of the projects are small and fairly straightforward such as the demolition of 19 old military buildings at Curtis Bay, Maryland that were covered with asbestos siding. Other sites, such as the former NIKE anti-aircraft missile site near Phoenix, Maryland, in Baltimore County, presented more difficult challenges because chemicals from the site had moved into the groundwater supply, raising contamination levels. The same problem was found at the former NIKE site near Tolchester Beach on the Eastern Shore approximately three miles from the Bay shorelines. Both sites are now in the process of restoration.[37]

Facilities such as the sprawling Aberdeen Proving Ground present still more serious problems. Over the past 60 years, hundreds of thousands of rounds of ordnance have been tested at this installation, and many of its acres are extremely hazardous and toxic. Environmental restoration at this installation is extremely complicated and will take many years to complete. The Baltimore District has been working at Aberdeen for the past two years in a joint effort with the U.S. Geological Survey, the Corps' Mobile, Alabama, District, (which specializes in handling explosives) and officials from Aberdeen Proving Ground. Using one of the Corps' few remote control drilling machines, the team is making a series of test borings to determine the geologic structure of several areas where there may be buried unexploded ordnance and other hazardous materials. The drill is operated from a portable bombproof shelter using a closed-circuit TV system. The team is also drilling a large number of monitoring wells to determine the extent and seriousness of groundwater contamination.[38] In spite of such large-scale problems, the Baltimore District and the Office of the Under Secretary of the Army for Environmental Affairs expects to make steady progress in the removal of all major environmental hazards, not only at Aberdeen Proving Ground but at all current and former military sites in the Bay area.

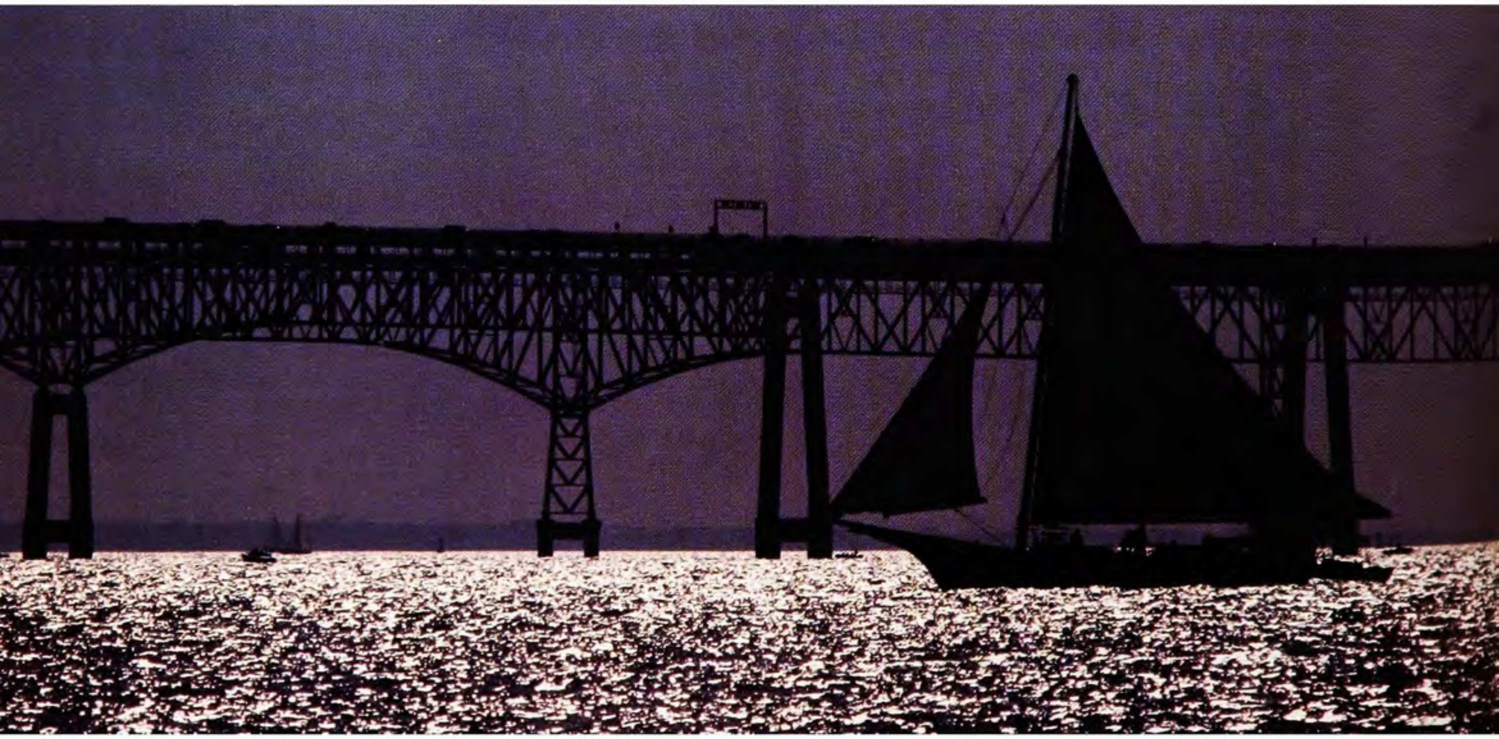
The state of Maryland and EPA have identified water quality as the most critical area of improvement under the Chesapeake Bay Restoration Program and the joint DOD-EPA resolution of 1984 obligated the DOD to give this the highest priority in its military facilities clean-up effort. Consequently, the Baltimore District was authorized to make a comprehensive and detailed analysis of the impact of all 66 of its military installations and facilities on water quality in the Bay.

The study was done in conjunction with a private contractor, Tetra Tech, Inc. of Alexandria, Virginia under the management of Steven D. Garbarino of the Baltimore District Environmental Analysis Branch. Each installation and facility was screened and those with small, moderate or significant impacts on water quality were identified. Those having significant adverse impacts were then studied in detail to define the exact nature and extent of their effect on water quality.[39] The final report was published in November 1987. It provides guidelines for a multi-million dollar pollution abatement program that will ultimately bring all Bay area military facilities into compliance with Maryland's and EPA's goals for water quality improvement in the Chesapeake Bay watershed.[40]

The Baltimore District's Chesapeake Bay Program duties, while important and far-reaching, form only part of the Corps' Bay-related activities. In fact, the Baltimore District probably handles a wider range of Bay-related issues and activities, both within and outside the formal Chesapeake Bay Program, than any other federal agency. To carry out these activities, the Corps has a statutory responsibility to weigh factors that are not always fully compatible with one another. Congress, Bay area state governments, and the majority of the region's people have made it clear that they wish to continue using the Bay and its watershed for many different purposes, but to do so more wisely than in the past. This is what the Corps of Engineers has been doing in its Bay-related activities for almost two decades. Lieutenant General E. R. Heiberg III, former Chief of Engineers, stated the matter succinctly at the 1985 Army-sponsored forum on the Chesapeake. He said, "The Army's role, through the Corps of

Engineers, is to help balance these multiple uses of the Bay with the obligation to protect a delicate ecological stability.''[41] No other federal agency has been given the opportunity, or the dilemma, of evaluating such a wide spectrum of interests and goals relating to the Chesapeake Bay. Therefore, an understanding of how the Corps' Baltimore District has attempted to do this over the past 20 years should provide a valuable insight into the larger effort to both use and protect one of the nation's greatest natural treasures.

In a joint effort for the military environmental restoration program, the Baltimore District works at Aberdeen Proving Ground, Maryland, with one of the Corps' remote control drilling machines.



Chapter II
The Chesapeake Bay and the Army Engineers

The Chesapeake Bay

The great Bay of the Chesapeake is the largest estuary in the United States and one of the largest in the world. Covering an area of approximately 4,400 square miles, the Bay is about the size of the state of Connecticut. Its ability to produce and sustain aquatic life is greater than any body of water its size on the planet. More than 2,700 species of plants and animals live in the Bay and its adjacent wetlands. Until its most recent decline, the catch of commercial seafood in a square mile of the Bay has been about four times greater than is caught in a square mile of the famed Georges Banks fishing area off Cape Cod.[1]

The tremendous aquatic productivity of the Chesapeake results from a unique set of conditions. The Bay is an arm of the Atlantic Ocean 4-30 miles wide that extends inland for a distance of 190-200 miles (depending on how the distance is measured).[2] It is a constantly fluctuating mixture of salty and fresh waters. The key factor in the Bay's hydrodynamics is the opposing forces of the ocean tides and river currents. The twice-daily flood tide brings billions of gallons of salt water into the Bay through its 11-mile wide mouth between Cape Henry and Cape Charles. This sea water soon begins to mix with the fresh water coming down from the fifty major rivers that flow into the Bay. Salinity levels in the Bay gradually diminish as one moves away from its mouth, but even in the upper Bay there is still a trace of salt. The salinity gradient forms the basis of a wide range of local aquatic and environments within the Bay which enables it to produce and support such an astounding variety of aquatic creatures.

In terms of geological time, the Bay we know today is quite young. Twenty thousand years ago it did not exist. Back then, the Susquehanna River flowed through an area we would have to call the "Chesapeake Valley," past Norfolk and on through a lowland area we now refer to as the continental shelf, emptying into the Atlantic Ocean many miles east of its present mouth. About 15,000 years ago the water level of the world's oceans began to rise and the Atlantic slowly moved up and across the continental shelf.

Ten thousand years ago, the ocean reached the

present entrance to the Bay at the Virginia capes near Norfolk. It took another 7,000 years for the sea to move up the valley of the Susquehanna to its present meeting point with that river at Havre de Grace, Maryland. This profound transformation of our coastal region was due to the waning of the last ice age and the partial melting of the gigantic polar ice caps. Trillions of gallons of water from the melting ice raised the level of the oceans approximately 300 feet during the previous 15 millennia. Intrusion of the ocean onto the continental shelf created the Chesapeake Bay and all the other bays and sounds along the East Coast of North America. This is not the first time the ocean has moved over the continental shelf and "drowned" the lower valley of the Susquehanna. There have been numerous earlier ice ages where the ocean levels have receded and the Chesapeake Bay became a wooded valley again. During these ice ages, all the rivers that now flow into the Chesapeake were then tributaries of the mighty Susquehanna: the Patapsco, Choptank, Severn, Potomac, Wicomico, Rappahannock, and York joined the Susquehanna in its beautiful wooded valley.

This lower Susquehanna valley was not very deeply cut into the land. It is relatively broad and, except for the stream bed of the Susquehanna itself, rather flat. Consequently, when the ocean began its march up the valley, it created an estuary that is generally quite shallow. The average depth of the Bay is 28 feet and two-thirds of it is 18 feet or less.

For example, if one were to sail across the Bay from Point Lookout at the mouth of the Potomac, to the fishing village of Ewell on Smith Island, the distance is about 16 miles. Smith Island lies about 6 miles off the Eastern Shore opposite Crisfield, Maryland. After sailing out from Point Lookout for a distance of approximately 7 miles, the depth would increase gradually to 100-120 feet as the boat passed over the old bed of the Susquehanna River. Once past this 1.5 mile wide trench the water would rapidly become quite shallow again, varying from 13-30 feet. As one approached Smith Island the markers for the dredged entrance channel would need to be sought out to keep from running aground. Sailing the 6 miles from Smith Island to Crisfield on the Eastern Shore, one would be in water 6-15 feet deep except when passing over the narrow bed of the old Nanticoke River which now lies under Tangier Sound. For over 18 miles of this 22-mile voyage, one would be in waters of 30 feet or less. In sum, the Chesapeake is a shallow pan of water into which have been incised a few deep troughs by the pre-Bay Susquehanna and its ancient tributaries.

What the Bay lacks in depth, it makes up for in the length of its shoreline, which twists and turns for over 7,000 miles along the Bay and the tidal portions of its tributaries. This extremely long shoreline, with its shallow waters and marsh lands, is another key factor in the Bay's outstanding potential for the production of aquatic life. There is 1.6 miles of shoreline for every square mile of Bay water surface. By comparison, the Great Lakes on the U.S.-Canadian border have approximately 240 feet of shoreline for each square mile of water surface.[3] The submerged aquatic vegetation (SAV) that grows along the Chesapeake's seemingly endless shoreline and adjacent marshes provides most of the organic materials which form the basis of the Bay's food chain as well as the habitat for plankton, oysters, crabs, fin fish, ducks and hundreds of other forms of animal life. The grassy shallows and marshes also act as important filters for excess sediments and other harmful substances otherwise carried into the Bay.[4]

The shallow waters surrounding the Bay are its chief source of productivity, but they also constitute the chief impediment to man's use of the estuary. Almost every harbor on the Bay must be dredged and redredged to keep it open even for relatively shallow draft boats. The larger commercial channels must be far deeper—30-50 feet. How to dredge these channels and dispose of the millions of square yards of dredged materials in an environmentally sound, but economically realistic manner, has become one of the Bay's critical management issues.

The great variety of aquatic life living in the Chesapeake depend heavily upon the shallows and marshes, but the whole process is facilitated by the unusual hydrodynamic system of the Bay. J. R. Schubel, in his book *The Living Chesapeake*, has described the Bay as a huge mixing bowl of salt and fresh water. Salt water moves into the Bay on the tide, billions of gallons of sea water moving up the Bay at speeds of up to 200 feet per minute (approximately 2 knots). It quickly meets the fresh waters discharging from the Bay's rivers at approximately 76,000 cu. ft. per second.[5] The lighter fresh water tends to slide over the denser, heavier salt water so the deeper waters are always saltier than those nearer the surface, and the degree of difference in salinity between the two layers is fairly consistent over most of the Bay. Since the Chesapeake is a long narrow estuary, the salt water has increasing difficulty moving up toward the mouth of the Susquehanna.

The salty and fresh waters would not mix very much were it not for the tide. Schubel calls it the Bay's "egg beater."[6] It moves up and down the Bay pushing the lower layer of saltier water northward under the freshwater layer that is being forced by the rivers down toward the Virginia capes. The tidal current it-

self often flows in opposite directions in the upper and lower Bay. For example, two hours after maximum ebb tide at Baltimore Harbor (located about two-thirds of the way up the Bay) the tidal current is flowing back toward the Virginia capes to a point just below Kent Island, but south of that point the next flood tide is already moving the waters northward. Two hours later, the flood tide has reached Baltimore Harbor, and in one more hour will finally have reversed the flow up at Elk Neck. By this time water in the lower Bay has already begun to flow back out into the Atlantic.[7]

The constantly fluctuating tidal motion together with the wind causes the majority of mixing in the Bay. Both a vertical and horizontal gradient of salinity exists in the Bay. Also, the rotation of the earth (the Coriolis effect) deflects the seaward flowing upper layer of fresher water toward the Western Shore, while the lower layer, being pushed by the flood tide in the opposite direction, is deflected toward the Eastern Shore so that Eastern Shore waters are always somewhat saltier. The western shore waters are also fresher because the Bay's major tributaries all enter from the west. The whole process is very complex and changes almost hourly with fluctuations in the tide, wind and temperature. There are also cycles of longer duration related to the changing seasons. These affect the tides, prevailing winds, and temperature in the Bay itself; and also control the rainfall in its watershed (which determines the amount of fresh water entering the Bay). The annual fluctuations of inflow from the rivers has a noticeable effect on salinity levels throughout the Bay. In the late summer and fall, when river inflow is generally lowest, water in excess of 20 parts salt per thousand, which generally stays down in the lower Bay, moves 25-30 miles north. During a drought it can move as much as 40 miles north, exerting a dramatic impact on a large number of aquatic plants and animals.[8] It is easy to see why scientists have had great difficulty unraveling the mysteries of such a body of water and why those who must make decisions that will change the Bay need to weigh so many factors before taking action.

Human Settlements in the Chesapeake Region

A substantial number of Indians lived in the Bay region for several thousand years before the coming of the Europeans. Their numbers were, however, small compared to the rapid increase that began in the late 17th century and which has escalated rapidly again in the latter half of the 20th century. Of equal importance, the Indians cleared very little land and thus contributed almost no additional sediments to those which flowed naturally into the Bay. It is, of course, sedimentation that will eventually fill in the Bay over the coming centuries.

The first significant impact of human settlement on the Bay begins in the late 17th and early 18th centuries with the coming of the Europeans. The Chesapeake region immediately attracted the attention of the earliest European explorers who were struck by its beauty, abundance and potential commercial utility. In 1572 a Spanish priest, Brother Carrera, said the estuary "is called the Bay of the Mother of God, and in it there are many deep-water ports, each better than the next." A generation later, Captain John Smith pronounced that "heaven and earth never agreed better to frame a place for man's habitation."[9] It was these sorts of enthusiastic reports that led to the first permanent European settlement in North America on its shores at Jamestown on the tidal reach of the James River above present day Newport News. Even earlier, in 1587, Sir Walter Raleigh had planned to settle his colony in the Norfolk area, but contrary to his instructions, they were deposited 70 miles south on Roanoke Island. This small "lost" colony probably left Roanoke Island sometime before 1590 and settled on the Chesapeake Bay near the present site of Norfolk. There they remained, living with a small tribe of friendly Indians, whom Captain John Smith said were called "Chesapeakes" until they were killed by Chief Powhatan's warriors in 1607, shortly after (and because of) the appearance of the Jamestown colonists in April of that year.[10]

The Jamestown Colony struggled for survival for a few years until its settlers turned to the growing of tobacco. In spite of the view of England's King James that the yellow weed was "loathsome to the eye, hateful to the nose, harmful to the brain" and "dangerous to the lungs," the tremendous popularity of tobacco in England and Europe drew thousands of immigrants to the Chesapeake region in hope of growing rich through its cultivation. By 1640, they had moved up the James River as far as present day Richmond. Farther north, on a tributary of the lower Potomac, Charles Calvert established a second colony in 1634 which he named Maryland. These colonists also quickly began to cut down the forests to make way for tobacco fields. By 1700, all the tillable land surrounding the Chesapeake Bay had been settled and the dense woods cleared for miles up its tributary rivers.

The Bay's watershed began to change. For the next century, tobacco ruled the Chesapeake economy, but gradually grain, corn and other agricultural crops also became profitable. More land was cleared and farmers ploughed the soil more deeply for the new crops. The

major avenue of trade was the Bay itself which, by the 18th century, was crowded with hundreds of ships. They carried the agricultural products of the Chesapeake region to England, returning in a few months with manufactured goods to be sold at Norfolk, Yorktown, Alexandria, Annapolis, Baltimore and dozens of smaller ports around the Bay.[11]

By 1765, the entire watershed of the Chesapeake, except for the portion in upper Pennsylvania and New York, had been settled. Approximately 700,000 people lived in the Chesapeake region, a larger proportion than any other watershed of North America. New England, the next largest region, had 600,000, but contained several separate watersheds. The land directly adjacent to the Bay and its rivers was often the most intensively tilled acreage, and was therefore most completely stripped of its natural vegetation. This increased soil erosion from four to eight times the natural rate. Streams and whole rivers turned brown as topsoil was carried down to the Bay. The once clear Chesapeake became increasingly murky. During the 19th century this agricultural run-off was augmented by the millions of tons of sediments washed down the Potomac and Susquehanna from coal mining. The effects of all this siltation on the aquatic life of the Bay did not become apparent until the 20th century, but its effects on the Bay's ports became painfully evident by 1760 and steadily worsened over the next 150 years. Siltation virtually shut down some Bay ports before the end of the 18th century. Jappa Towne, the bustling port and county seat of Baltimore County in the early 18th century, silted up rapidly, lost its place as the county seat in 1768, and was largely abandoned by 1800. Its archeological remains now lie almost 2 miles from the present shoreline.[12] Other colonial era ports shoaled up more slowly and were able to survive the loss of their navigability by turning to other economic activities. Places like Elk Ridge, Port Tobacco, Upper Marlboro, and Bladensburg are still on the map, but maritime trade is obviously not their source of wealth. The Bay's larger ports, with a greater investment in shipping, began to keep their channels open by dredging. Baltimore, whose Inner Harbor had a depth of only 9 feet by the end of the 18th century, began to dredge a deeper channel.[13]

One positive by-product of the increased sedimentation was the growth of marshes and wetlands around the Bay. The sediments of the late 18th and 19th centuries were often trapped near the shoreline by submerged aquatic grasses and gradually built up to the point where they rose above the water line at low tide, turning formerly underwater areas into intertidal wetlands. These unique areas probably reached

The Chesapeake Bay area contains 20,600 square miles of land and comprises nearly one-fourth of the Bay watershed.

their peak coverage in the middle or late decades of the 19th century. Since that time, the loss of wetlands has exceeded the rate at which new acreage was being created. This has been due to a number of factors both natural and man-made. The most obvious human factor has been the filling in of tens of thousands of acres of wetlands over the past 200 years—a process that greatly accelerated after 1920. Wetland filling has been particularly rapid in the more urbanized areas of the Bay such as Baltimore, Annapolis, Washington, and the smaller ports and towns on the Eastern Shore. One estimate places the net loss of wetlands prior to the 1970s, when protective legislation was passed, at a minimum of 1000 acres per year in the Maryland portion of the Bay alone. The remaining wetlands in the Maryland portion of the Bay now cover 244,000 acres, but 67% of these wetlands are located in Dorchester and Somerset counties, the two southernmost counties of the Eastern Shore. Only 20% of the state's total Bay wetlands (51,000 acres) lie on the western shore where the great majority of the population lives and where the greatest wetland losses have occurred in the past. The upper Eastern Shore is the next most rapidly growing area of the Bay and it has only 31,000 acres of wetlands.[14] Thus the portions of the Chesapeake having the least amount of wetlands are under the greatest pressure from Bay area residents.

The Chesapeake Bay area, as defined by the Baltimore District of the Corps of Engineers in its *Chesapeake Bay Study,* consists of sixty-one counties and twenty cities adjacent to or directly influencing the Chesapeake Bay and the estuarine portions of its tributary rivers (see map). The area contains approximately 20,600 square miles of land and comprises nearly one fourth of the total Bay watershed. In 1765, about 700,000 people lived here. By 1940, the population had grown to 3.7 million, a modest growth rate of about 22,000 per year. Then came the demographic flood. Between 1940 and 1980 the region added another 4.8 million residents—a growth rate of 120,000 per year! This tremendous influx of residents into the Bay area is predicted to slow down slightly over the next 40 years, but not by very much.[15]

The current population projection of the Corps of Engineers, based on data from the Department of Commerce Economic Research Service, indicates that by the year 2020, the Bay area will contain 16.3 million people. Close to three quarters of them will live in the Baltimore-Washington metropolitan area on the western shore and will therefore have ready access to the Bay. The Eastern Shore has no metropolitan areas of significant size, so its growth will be far less, but the use of this area by others, including the building of second homes and recreational facilities, will increase substantially. The Baltimore-Washington metropolitan area is the fourth largest in the United States. It has the highest median household income and the largest percentage of professional and administrative workers in the United States.[16] This large number of well-educated and affluent people spends a substantial portion of their leisure time on the Bay. Small Eastern Shore communities such as Rock Hall, Maryland, have come under increasing pressure to allow the construction of very large waterside vacation/retirement developments.[17] The construction of a second Chesapeake Bay bridge some 30 miles below the present one, a project under study by the state of Maryland, could also have a profound effect on population and recreational growth along the middle and lower portions of the Eastern Shore.

The dramatic change in Bay area population over the past 40 years has exerted an equally striking impact on land use that will continue into the next century. In 1940, urban lands in Bay areas accounted for only 2% of the total land area. By 1970 this had grown to 7% and experts predict it will increase to almost 15% by 2020. This probably is a conservative estimate since the most recent studies have shown that land in the Bay area is being converted from forest or agriculture into urban/suburban uses at twice the rate of population growth.[18]

At first glance, it would seem that the loss of Bay area land to urban/suburban uses does not pose a major land problem. Urban/suburban land uses currently occupy about 1,500 square miles. The urbanization of an additional 1,500 square miles within the Bay area still leaves 17,600 square miles for other uses. There will also be a decline in agricultural land amounting to almost 1,400 square miles by the year 2010 that might appear to balance the need for new urban/suburban growth. However, it is misleading to think there are no significant land-use conflicts. The Baltimore District's *Chesapeake Bay Study: Summary Report* stated that while there will be quite enough land for urban development in terms of total supply, the specific locations of urban land conversion is a serious problem. The report noted especially the difficulties arising from urbanization and the growth of vacation homes and recreational facilities along the shores of the Bay and its rivers. It also noted larger-scale conflicts.

> Often the best agricultural lands or the most productive forests are also desirable for urban development. Without proper planning, areas of special ecological, historical, or archaeological significance may be destroyed.[19]

Clearly, the pressure of population on the Chesapeake Bay and its surrounding watershed has increased enormously in the past forty years and shows every indication of continuing for at least the next forty years. The various ways in which the present and future population uses the Chesapeake Bay will largely determine whether it will become a more healthy and productive body of water or a "Water Wasteland."

The Corps of Engineers and the Chesapeake Bay

The Army engineers have been working in the Chesapeake Bay area since 1794, when they began the task of turning a temporary earthwork defense at the entrance to Baltimore Harbor into the structure we know today as Fort McHenry. In 1814, this strong fort, as well as two other artillery positions in the harbor also built by the Army engineers, withstood the attack of the British fleet sent to destroy the city. The "Star Spangled Banner" that waved over Fort McHenry during the bombardment provided the inspiration for Francis Scott Key to write the words which became the national anthem.[20]

Following the war, the Congress initiated a major coastal defense construction program for the Chesapeake Bay which the Corps of Engineers carried out over the next century. Fort Monroe and Fort Calhoun

were built at Hampton Roads near the entrance to the Bay and the defenses of Baltimore were substantially strengthened. Fort McHenry was enlarged and strengthened and a second fortress, named Fort Carroll was constructed on a shoal in the middle of the Patapsco River several miles below Fort McHenry. The first three years of its construction were supervised by Captain Robert E. Lee, the most famous of the Baltimore District's engineers. Eventually three more coastal fortifications were built around what is today the outer harbor area of the port. These are Forts Howard, Smallwood and Armisted. By the time of the Civil War, Baltimore was one of the best defended ports in the world. The forts at Hampton Roads and Baltimore continued to play a role in the defense of the Bay through the First World War and exist today as reminders of that earlier age and the skill of the engineers who constructed them.[21]

Unlike the handsome and visually striking fortifications, the greatest engineering achievements of the Baltimore District in the Chesapeake Bay cannot be seen, even if one is right on top of one of them. These are the numerous Bay shipping channels the Corps designed and constructed over the past 136 years. Their effects, however, are more significant than all the old forts. They are to be seen in the dozens of Bay ports that owe such a large part of their commercial life to this vast network of underwater highways. Among the channels of the Bay, the Baltimore Harbor Channel is by far the most significant. Longer, wider, and deeper than any other channel in the Baltimore District, it is of overwhelming importance to the economy and people of the entire Bay region.

Baltimore would have remained a quaint little 18th century town on the Patapsco River had it not begun dredging a channel in the outer harbor just beyond Fort McHenry. Since the city's port activities were vital to the economy of the entire mid-Atlantic region, the federal government began providing financial aid to the city of Baltimore in 1836 to improve this channel. Progress was slow until 1852 when Captain Henry Brewerton arrived in Baltimore as the Corps' District Engineer. The arrival of this talented engineer coincided with renewed congressional interest in commercial growth. The federal government authorized the Corps of Engineers to survey and construct a channel from Fort McHenry all the way out into the deep waters of the Bay. Between 1852 and 1858,

In 1814, the flag flying while Fort McHenry withstood the attack of the British fleet inspired Francis Scott Key to write the words for the "Star Spangled Banner."

Brewerton surveyed and dug the channel that still bears his name. As soon as the new channel was completed, ships that had avoided the dangerously shallow Patapsco now entered it, and Baltimore's maritime economy thrived.[22]

The deepening of Baltimore's channel from 17 to 22 feet was a great improvement, but even before this project was completed, it became apparent that larger ships were going to be built that would require a wider and deeper channel if the city was to remain competitive. The task was undertaken by Major William P. Craighill, who succeeded Brewerton in 1866. For the next thirty years this remarkable man, building on the work begun by Brewerton, created the modern ship channels for the Baltimore Harbor. His first problem was the lower portion of Brewerton's channel. It ran straight down the Patapsco past Fort Carroll and to this point remained in good condition; but the lower portion, beyond the fort, had shoaled considerably from the action of a complex set of currents where the Patapsco flowed into the Bay. Drifting bottom sediments were filling the dredged channel faster than the Corps could dig it out. Craighill's analysis of the current that controlled the movement of sediments led him to turn the direction of the channel south for 3 miles before turning out again in a southwest direction into deep water. The design was a great success. Instead of moving sediments into the channel, the current now tended to scour them out. The Craighill Channel is still the main entrance to the Port of Baltimore.[33]

Major William P. Craighill created modern ship channels for Baltimore Harbor.

The Civil War halted further improvements for a decade, but between 1872-1883 all of Baltimore's channels were deepened to 24 feet and widened from 200 to 600 feet. City leaders were delighted, but the Patapsco watermen complained that the dredging and dredged material disposal ruined their oyster beds. They complained again in the 1890s when Congress ordered the channels deepened to 30 feet. The Craighill Channel cut right through several valuable oyster beds and the millions of tons of dredged material dumped overboard added to the problem. The total destruction of the Patapsco's oysters came, however, not from dredging, but from the sewage and industrial wastes being poured into the harbor by the growing city.[24]

Nevertheless, the removal of tremendous amounts of dredged material continued to raise questions about its disposal. By 1900, nearly 30 million cubic yards of dredged material had been removed from the Baltimore channels. The great majority had simply been dumped overboard near the channel. It became apparent that such practices led not only to the smothering of oyster beds, which Craighill regarded as an unfortunate but necessary sacrifice to the greater economic benefits of commercial trade, but also resulted in varying amounts of the dredged material being gradually moved by the currents back into the channel at some other point. Colonel Peter C. Hains, who followed Craighill as the Baltimore District Engineer, recognized the seriousness of the problem and recommended that future disposal of dredged material be made behind bulkheads on the shore—a "solution" that simply caused new problems. The disposal of dredged material is a problem that the Corps of Engineers and local interests have been struggling with for many decades.[25]

Baltimore was not the only harbor to receive attention from the Corps during the 19th century. Beginning in 1870, Congress authorized dozens of small channel improvement projects for rivers and towns throughout the Bay. Deeper and wider channels were constructed by the Baltimore District at Havre de Grace, Elkton, Queenstown, Rock Hall, Chestertown, Cambridge, Seaford (Delaware), Salisbury, Pocomoke, Annapolis, Alexandria (Virginia), Washington, DC and a score of other rivers and ports around the Bay. Thus began the Bay-wide channel improvement program. Once the benefits of the new channels were seen, there was constant pressure from local groups in every Bay town to expand channels to accommodate larger vessels. For example, at Cambridge, Maryland, on the Eastern Shore, the 1870 Rivers and Harbors Act authorized a channel 10 feet deep and 100 feet wide. The sleepy village of 1870, with barely 3,000 residents, suddenly experienced a rapid growth in its economic activity and population, becoming a real town for the first time. By 1910, its population reached almost 8,000. Since that time, Congress has ordered the Corps to expand the depth, width and length of the Cambridge Harbor channels nine times.

Baltimore (right, shown in 1938 in this photo from the Library of Congress) was not the only harbor to receive attention from the Corps. Bay-wide channel improvements brought rapid growth in economic activity and population (above) during the 19th century.

The main commercial channel is now 25 feet deep and 150 feet wide.[26]

The channel improvement projects provided a real economic stimulus for the Bay's villages and towns, since they could all now accommodate larger vessels. The commercial effects of the program were particularly significant for the Eastern Shore. Harold K. Kanarek, historian of the Baltimore District, states that the whole region experienced a "dramatic change" during the late 19th century as a result of the channel improvements. Railroads had done relatively little to link Eastern Shore communities to the outside world, so the increased Bay trade opened new markets and stimulated economic growth such as these towns had not seen for a very long time and would not witness again until the construction of the Bay bridge and the growth of the vacation industry in the post World War II era.[27]

Thus, by the opening of the 20th century, the Baltimore District's engineers had built a Bay-wide system of shipping channels that allowed Baltimore to become one of the nation's greatest ports, and had significantly improved the local economy of smaller towns and villages throughout the Bay. The district's coastal defense program, which continued to improve Fort McHenry and several other Bay fortifications, was now clearly overshadowed by the navigation channel activities. The need to defend the Bay against attacks by an enemy fleet seemed by this time to be fairly remote and neither Congress nor the Corps gave much attention to the issue. Certainly no one expected that sixty years later the Chesapeake would again be under attack and would require the Corps to give close attention to its defense. This time, the enemy was not a British fleet. It was the unwitting environmental destruction of the Bay by its own residents and users. As a result, the Baltimore District is now helping build an environmental analog to Fort McHenry that will, it is hoped, defend the ecological health of the Chesapeake just as effectively as its forts once protected the security of its residents.




Chapter III
The Chesapeake Bay Studies, 1961-1983

While the Corps of Engineers had undertaken a great many individual projects in the Chesapeake and its watershed since the early 19th century, it was not until 1961 that Congress asked the agency for a survey of the entire Bay. Why did it take so long? The most plausible answer is that few officials or political leaders really perceived the Bay as a single unit until quite recently. Politically and administratively, the Chesapeake watershed is divided among five states and over 100 local governments. The Bay itself is divided between Maryland and Virginia and the two states have long disputed its use.[1] Even today the Corps of Engineers divides the Chesapeake between its Norfolk and Baltimore districts along the Maryland-Virginia line. This gives the Baltimore District authority over approximately two-thirds of the Bay and its shoreline. The district also encompasses about three-quarters of the Bay watershed.

In 1961 the Senate Select Committee on Water Resources requested the Corps of Engineers to provide a brief survey of the general condition of water resources in the Chesapeake Bay basin along with a projection of future needs. This was part of a larger effort by the Senate Committee to gather material on major watersheds to assess national water resource needs. The Chesapeake survey was assigned to the Baltimore District. The resulting document, *Chesapeake Bay Basin Study: An Appraisal of Water Resource Needs Projected to the Year 2060*, provided the first attempt by any governmental agency to assess the condition of the entire Bay and its watershed.[2] In spite of its brevity, the study identified many of the Bay's major problems that drew so much attention in the ensuing two decades. The fundamental threat to the Bay, stated the report, was the accelerating population and economic growth of the area's metropolitan regions. This was causing major increases in the volume of suspended solids in the Bay's rivers as well as larger withdrawals of water for urban consumption. The report noted the increasing pressures on wetlands, the depleted fish populations, real estate developments on areas subject to tidal flooding and wasteful or harmful local schemes to try to prevent shoreline erosion. Pollution from many sources had already caused great concern and was clearly endangering the aquatic health of many areas within the Bay system. The increasing scale of dredging posed problems for the future since, in combination with large withdrawals of water from the rivers, it could increase salinity levels and cause further harm to Bay organisms. The disposal of dredged material, the study warned, "has become an acute problem."[3] As the Bay area population swelled, all these problems would become even more critical.

A 1961 Chesapeake Bay Basin study warned that disposal of dredged material was already an acute problem.

> Perhaps because of the vast expanse of the Bay and its many tributaries, there has prevailed in the past an attitude that all interests can be accommodated without conflict. The increased, almost explosive, recreational pressure now being exerted on the resource, coupled with the use of the Bay for waterborne commerce and seafood production, makes it apparent that a comprehensive, fully integrated master plan is required if optimum development of the Bay's resources is to be realized.[4]

The survey's alarming projections, along with similarly pessimistic reports from Maryland, Virginia and several Bay area universities over the next several years led a group of Maryland congressmen to ask for a much larger study of the Bay and its watershed, including the construction of a gigantic hydraulic model of the Bay—a project strongly supported by the Corps. The chief supporters were from those congressional districts adjacent to the Bay, represented by Rogers C.B. Morton and George A. Fallon from Maryland and Hervey G. Machen and Thomas N. Downing of Virginia. Several congressmen visited the Corps' hydraulic model of San Francisco Bay and were impressed by its usefulness in offering new insights for that estuary. The proposed Bay study was included in the Rivers and Harbors Act for 1965. The study was to be carried out by the Baltimore District in cooperation with the Philadelphia and Norfolk Districts and other federal and state agencies concerned with the Bay. In addition, Baltimore District was directed to build a hydraulic model of the Chesapeake to be used to gather information and assess future Bay conditions.[5]

The Chesapeake Bay Study, legislated by the Rivers and Harbors Act of 1965, directed that the Baltimore District build a hydraulic model of the Chesapeake to gather information and assess future Bay conditions. Supporters were optimistic that the Bay's problems could be readily identified and solved.

During hearings on the proposal before the Subcommittee on Rivers and Harbors in 1965, all witnesses and subcommittee members supported the project and a number of them expressed optimism that the Bay's problems could be readily identified and solved. There was an expectation on the part of several congressmen that the Chesapeake Bay Hydraulic Model would be able to provide all the answers. This highly optimistic expectation of quick answers was based in part on the fact that few people outside the scientific community, or of agencies such as the Corps, understood the complexity of the Bay's hydrography and ecosystem or how difficult it was to devise a balanced water resource management plan. Also, the capabilities of hydraulic models were exaggerated. Colonel Crawford Young, Assistant Director of Civil Works for the North Atlantic Division, testifying on behalf of the Chief of Engineers, cautioned the subcommittee that even such a large and magnificent instrument as the proposed Bay hydraulic model could not be expected to provide all the information everyone desired.[6] Nevertheless, it would represent a giant step forward for Bay research.

Legislation for the Chesapeake Bay Study and construction of the hydraulic model was signed by President Lyndon B. Johnson on 27 October 1965 as Sec. 312 of the Rivers and Harbors Act of 1965. The provision stated that:

> Sec. 312. (a) The Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to make a complete investigation and study of water utilization and control of the Chesapeake Bay Basin, including the waters of the Baltimore Harbor and including, but not limited to, the following: navigation, fisheries, flood control, control of noxious weeds, water pollution, water quality control, beach erosion, and recreation. In order to carry out the purpose of this section, the Secretary, acting through the Chief of Engineers, shall construct, operate, and maintain in the State of Maryland a hydraulic model of the Chesapeake Bay Basin and associated technical center.[7]

The Baltimore District began work on the Chesapeake Bay Study in 1967. The "Plan of Study" stated that the project was to be a "multi-disciplinary study encompassing engineering, and the physical, biological, and social sciences."[8] Identification of the Bay's existing and future conditions would be accomplished through a Bay Study Advisory Group composed of representatives from Virginia, Maryland, Pennsylvania, Delaware and the District of Columbia as well as officials from all the relevant federal agencies and university marine research centers. Once formed, this advisory group discussed at considerable length the problems the Bay study was authorized to investigate and provided many useful ideas. It also heard views in a series of public meetings held by the Corps in towns and cities around the Bay in late 1967.

The advisory group was supported by five task groups formed to delineate the proper scope of each area to be investigated. A steering committee addressed the development of the hydraulic model and other technical matters. These working sub-groups provided much of the direction for the subsequent phases of the Bay study. There was a good deal of enthusiasm among the participants because it was the first time such a wide spectrum of research specialists, state officials, and federal representatives had been brought together to look at the entire Bay area and

examine its many problems. Several advisory representatives expressed their satisfaction that the study would address specific issues rather than the usual generalities.[9]

After much discussion by the advisory group and the Corps, it was decided to conduct the study in three phases. First, an assessment would be made of the existing physical, chemical, biological, economic, and environmental conditions of the Bay. Second, the study would project future water resource needs of the Bay region to the year 2020. Finally, it would identify the priority water resource problems of the Bay and, with the aid of the Chesapeake Bay Hydraulic Model, recommend actions to address these problems.

Chesapeake Bay Existing Conditions and Future Conditions Reports

The *Chesapeake Bay Existing Conditions Report,* issued in 1973, was the first major product of the Bay study. Included in this seven-volume report was a description of the physical, economic, recreation, social, biological, and environmental conditions of the Bay. It provided the public and government agencies with a comprehensive survey of the Bay and assembled much of the data required to project future needs in the Bay area and the problems that would arise in the attempt to satisfy them.

The report provided a pioneering economic and demographic history of the Chesapeake region, drawing public attention to the fact that the long period of slow, steady economic and population growth around the Bay had changed sharply since 1940. The key factor was the rapid growth of metropolitan Baltimore, Hampton Roads and especially Washington. It noted that the region had lagged behind the nation in population growth since the early years of the 19th century, but between 1940 and 1970 had grown at a rate double that of the United States as a whole. It also noted that the excellent economic progress of the Bay area had also been accompanied by "environmental insensitivity by both industry and the public."[10]

The report presented a comprehensive analysis of the Bay's immediate hinterland, that is, the region adjacent to the Bay and the tidal portions of its tributaries. It presented detailed data on the region's geology, climate, soils, surface and ground water hydrology, mineral resources, land use and land-use planning procedures, shoreline use, erosion and sedimentation.

Turning from the land to the water resources of the Bay and its tributaries, the report presented compre-

hensive data on water supply in the entire Bay area (municipal, industrial and agricultural). It described water quality in 34 of the Bay's major tributary rivers and streams as well as its more important harbor areas. It presented detailed information about recreational facilities on or adjacent to the Bay, finding, for example, 20,200 camp sites and 26,600 picnic tables in the Bay area.[11]

The last section of the report was given the title "The Bay: Processes and Resources." Noting that knowledge of the Bay's ecosystem was still quite sparse, the study provided an overview of the natural and man-made forces operating in the Bay and its watershed and the manner in which they interacted with the 2,742 species living in its waters, a process which in some cases had major indirect effects on Bay area residents.[12] The report examined shoreline erosion, tidal flooding, navigation and dredging, noxious weeds, fish and wildlife, and Bay biota. Problems in all these areas were readily apparent. Shoreline erosion was causing an annual loss of approximately 460 acres of land each year. It has since been estimated that over the past century, over 45,000 acres of land along the Chesapeake shoreline has been lost. This is an area approximately the size of the District of Columbia.[13] The report looked at the series of devasting hurricanes that have swept across the Bay or its watershed, inflicting extensive flood damage from wind, tidal surges and tributary flooding. This section was quite timely. As the report was being prepared for publication, tropical storm Agnes moved through the mid-Atlantic region causing extensive damage to the resources of the Bay. Shortly thereafter Congress authorized funds for the Corps to conduct an analysis of the storm's effects on the Bay. This study was published in 1980.[14]

The Chesapeake shoreline lost an area the size of the District of Columbia to erosion during the past century. Erosion shown here is at Barren Island.

The section of the Bay Study dealing with navigation highlighted the problems associated with dredging and the disposal of dredged material—an economic and environmental problem of which the Corps was already keenly aware. A long section on the commercially significant fish and wildlife of the Bay, plus the other biota in the Bay's complex food chain, raised issues that were to be more closely examined in later stages of the Corps' Bay Study or were included in the EPA's Bay water quality study, which began in 1973. These were issues surrounding the presence in the Bay of: 1) toxic pollutants from industrial sources, 2) non-toxic pollutants such as silts, clay and other sediments, 3) oxygen-removing pollutants such as organic plant and animal wastes, or artificial nutrients which caused over-enrichment and eutrophication, and 4) modifications in the salinity level which can affect certain types of aquatic life.[15]

The appearance of the *Existing Conditions Report* in 1973 is a significant chapter in the history of Chesapeake Bay research because it provided the most complete picture of the Chesapeake Bay region ever assembled up to that time. It is still a useful data base against which to measure the progress made since 1973. Finally, it intiated the process of identifying some of the specific Bay-wide problems and issues that would be treated more extensively in later stages of the Bay Study.

The *Chesapeake Bay Future Conditions Report*, released in 1977, projected the demands that would be made on the water resources of the Bay to the year 2020.[16] Projections were based on per capita trends in the use of water resources and the projected growth of the total area population. Almost all the data collected by the Corps indicated that per capita consumption lev-

els and total population would continue to grow fairly rapidly in the Bay region. In other words, each Bay area resident would be using more water in the year 2020 than his or her counterpart did in 1977, and the total number of users would be substantially larger. Population projections were developed for the Corps by the Commerce Department's Bureau of Economic Analysis (BEA), then called the Office of Business Economics. The figures at that time indicated a Bay area population of 16.2 million by 2020. In the years since the *Future Conditions Report* was put together, the BEA has revised downward its Bay area population projections, reflecting the slower growth of the 1970s.[17] Ironically, just as the BEA was putting out its revised projections in 1981, the Bay area economy began growing more rapidly, especially in the Washington-Baltimore metropolitan area, raising the possibility that the forecasts may have to be revised again in an upward direction. The fundamental difficulty is that the entire regional, national and international economy is changing swiftly and with these changes come equally rapid population shifts. In such a world, population projects are often of relatively little value as a long-range planning tool.

In Norfolk, Virginia, tidal flooding from storms and hurricanes remains part of the Bay scene.

Even with the lower population projections, the *Future Conditions Report* showed that the majority of the region's water supply systems, for example, would have average daily water demands by the year 2020 in excess of their present capacity. Peak periods of water use, often coinciding with droughts, would place even greater demands on freshwater sources, diverting them from the Bay. [18] This was an issue that awaited more detailed and comprehensive analysis from the Chesapeake Bay Hydraulic Model.

Shoreline erosion was projected to continue to be a serious problem, particularly along the 410 miles of Bay shoreline identified as having a "critical" erosion problem. The seriousness of the issue was compounded by the increasing demand on shoreline property for a variety of residential, recreational and commercial uses.[19]

Tidal flooding from storms and hurricanes was another problem that would remain part of the Bay scene into the 21st century. Tropical storm Agnes was a sufficient reminder of this fact. Once again, the problem was clearly going to worsen in view of the projected increases in the development of low lands adjacent to the shoreline of the Bay. The exact delineation of the problem had to await the completion of more detailed studies.[20]

The future demands on the Bay for commercial shipping were projected to increase approximately 600% between 1972 and 2020 and the increase in recreational boating was expected to run about 500%. Commercial fishing boats were not expected to increase. The growth of shipping and recreational boating emphasized the need to give the most serious attention to the future of dredging and dredged material disposal.[21] At the very time the *Future Conditions Report* was released, a major public controversy over the deepening of the Baltimore Channel to 50 feet reached its most heated moments, and the Corps was rushing to complete the verification and calibration of the Bay Hydraulic Model to conduct a study of the Baltimore Harbor Channel deepening proposal.

In summary, the *Future Conditions Report* documented the many ways in which the Bay area's residents would increase their use of the Chesapeake and its watershed. It also identified more closely the problems that would result from these increases. Along with the *Existing Conditions Report*, the *Future Conditions Report* still represents the most complete study of the Bay area and its resources ever presented by any agency. In 1982, Professor L. Eugene Cronin, of Johns Hopkins University, one of the leading academic experts on the Chesapeake Bay, cited the two reports as the most extensive comprehensive description and projection of the Bay's uses, trends and potential problems. He thought they were of "exceptional value" for the development of Bay management programs by state and federal agencies.[22]

More specifically, the two reports identified a series of issues and problems the Corps of Engineers needed to examine in greater detail during the third and final phase of study. Some of these issues required field study while others were best looked at by the Chesapeake Bay Hydraulic Model which was, at this time, just about ready to use.

The Chesapeake Bay Hydraulic Model, 1973-1983

Of all the hydraulic models developed by the Corps of Engineers over the past 50 years, the Chesapeake Bay Hydraulic Model is probably the most spectacular and complex.[23] The 200,000 people who came to Kent Island, Maryland to see the model in operation enjoyed an unforgettable experience. Their first impression upon entering the 14-acre building that housed the model was its sheer size. They saw before them an eight-acre replica of the Chesapeake Bay. It stretched over a 1,000 feet from the Virginia capes to the north end of the Bay. A 21-foot long replica of the Chesapeake Bay Bridge crossed the water about 100 feet below the entrance to Baltimore Harbor. The "Bay" itself, holding 450,000 gallons of water, glistened under the hundreds of lights set into the rafters of the model shelter. Sitting above the water, and often poking into it, were hundreds of complicated-looking instruments linked by what seemed to be miles of wires. Huge pumps churned at the far end of the model and from around its "shoreline," strange futuristic looking nozzles poured streams of water. The nozzles or inflow devices represented the flow of the Bay's tributary rivers. The major rivers, the Susquehanna, Patapsco, Potomac, James, Pocomoke, Choptank, and Chester could all be seen, along with the Chesapeake and Delaware Canal, each with their own inflow control at the point where they discharge into the Bay. The Susquehanna and Potomac nozzles gushed forth in a large seemingly steady stream while other very small ones dribbled out a stream that was hardly detectable. The apparently steady streams that flowed from the Potomac and Susquehanna nozzles actually were in constant flux, replicating the daily changes in the river's flow through the annual cycle of seasons. Changes were controlled by a computer into which the average daily flow of all the Chesapeake's tributaries for each day of the year had been fed. Amidst this array of moving waters, scientists and technicians scurried from one instrument to another, stepping carefully over rivers

and inlets or crossing the entire "Bay" on long metal foot bridges.

The Chesapeake Bay Hydraulic Model was designed, built, tested and operated by the Corps of Engineers Waterways Experiment Station (WES) for the Baltimore District. The Experiment Station is in Vicksburg, Mississippi, but the Bay model, in conformity to the authorizing legislation, was built in Maryland on Kent Island within sight of the double-spanned Chesapeake Bay Bridge. The model was to be a pioneering effort since up to that time no one had built a hydraulic model of an estuary that would replicate so many of the complex dynamic processes found in such bodies of water. The Chesapeake Bay Model was designed to be capable of replicating the dynamic changes in freshwater inflows and tides over time, an awesome task. The project was perhaps the greatest challenge ever undertaken by the Waterways Experiment Station. WES had been building hydraulic models since the 1930s and had become one of the world's major centers of hydraulic modeling. However, this project called for development of a host of modeling techniques that had never been used, and new or modified instruments that taxed the limits of its engineers.

The first problem was the collection of what model builders call "prototype data," that is, the data on the actual body of water that is to be replicated in miniature by the hydraulic model. This prototype data was used in the verification process, to assure the model was performing exactly as the prototype under the identical circumstances. Existing data on the Bay were obtained from the U.S. Geological Survey (USGS), the Maryland Department of Natural Resources, and the National Weather Service. Additional data that needed to be collected directly from the Bay was collected by several agencies under contract to the Baltimore District: the National Oceanic and Atmospheric Administration (NOAA); the Johns

The fixed-bed Bay Hydraulic Model is molded in concrete to replicate the bathymetry of the Bay.

Hopkins University Chesapeake Bay Institute; the University of Maryland Biological Laboratory; and the Virginia Institute of Marine Sciences. The salinity and current velocity data were collected at 199 and 205 stations respectively. Norman Scheffner of WES developed a harmonic analysis procedure to extrapolate this data by programming a monthly lunar tide without which the model could not have been verified.[24]

The Bay Model was a fixed-bed type, molded in concrete to replicate the bathymetry of the Bay. Twenty-six miles of templates, conforming to the contours of the Bay and the tidal portions of its rivers, were laid on the floor of the shelter building. Concrete was poured between the templates and hand molded to replicate more detailed features. Even finer features that could not be molded in the concrete were simulated by implanting over 700,000 small metal strips into the cement. Each strip was bent to a configuration which imitated the degree of roughness on the bottom of the Bay. The water area of the model extended from the Atlantic Ocean off the Virginia capes to the head of tide of all the tributaries plus the entire length of the Chesapeake and Delaware Canal. The land area of the model included all land up to 20 feet above mean sea level.

The Bay Model was what is called a distorted model, which means that its horizontal and vertical scales, compared to the actual Bay, were not the same. The horizontal scale was 1:1000 while the vertical scale was 1:100. The reason for this is the shallowness of the Bay compared to its length and breadth. The deepest point in the Bay is 174 feet. In the Bay Model this spot was 21 inches deep, but since the average depth of the Bay is 20-30 feet, this is replicated on the model by only 2.4-3.6 inches of water. If a scale of 1:1000 had been used for depth as well as length, most of the model would have been only one-third to one fifth of an inch deep. After the horizontal and vertical scales of the model were established, the ratios of volume, velocity and time were automatically set. Each cubic foot of water in the model was equal to 100 million cubic feet of water in the Bay. Water velocities in the model were equal to one-tenth the velocities in the Bay. The time cycle on the model was far more rapid than "real" time. The model could be operated so that hydrological changes, a tide for example, that took approximately 12 and one-half hours on the Bay could be replicated in less than eight minutes. A whole year of Bay water movements could be run in just over three and a half days.[25] This was a tremendous advantage in conducting long-term studies that covered several years of "real" time, but it meant that the Bay Model staff had to operate the model 24-hours a day—sometimes for up to 30 days in a row. The model shelter was not heated or air conditioned, so during the winter the WES technicians worked in near freezing cold while in the summer temperatures rose to nearly 100 degrees inside the vast building.[26] Enclosing the model in a shelter was essential, however, since rain, wind, and debris had to be kept away from the model's water and its delicate instruments.

Water for the Bay Model was drawn from two wells adjacent to the shelter building and stored in a water tower. It entered the model as fresh "river" water squirted through one of the 21 freshwater inflow controls. These freshwater inflow controls, like many of the other instruments developed or modified for this project, were the ingenious creation of

The old method of learning how the Bay behaved was to get out in boats and take measurements over weeks, months or even years on the 4,400-square mile body of water.

James V. Tarver and other technicians from WES. The inflow controls were linked to computers that varied their flow to replicate any combination of flows desired by the staff over any length of time. For the Low Freshwater Inflow Test, they ran the Bay rivers as they had flowed during the drought of 1964-1966 and later as they might flow in the year 2020.

The water entering the model from the "Atlantic Ocean" portion of the model had first to be mixed with salt to achieve the exact salinity of the ocean. It was then pumped into the Bay Model between the Virginia capes (an opening about 60 feet wide on the model) by large pumps that simulated the incoming and outgoing tides. Since the time and velocity of the tides change according to the lunar cycle, the pumps had to be carefully controlled by the same computers that directed the freshwater inflow devices so for each day of the year exactly the right amount of salt water and freshwater entered the model at the same moment at the proper velocity. The model could not replicate all of nature's forces such as wind, rainfall or the Coriolis effect, but these were not major distorting factors for the tests conducted in the Corps program.

Once the Bay model was put into operation, how did the technicians know what was happening in its waters? For this purpose another series of remarkable precision instruments took constant readings of six basic water measurements. They measured water surface elevation, current velocity, salinity, dye dispersion and water temperature. The data from all these measuring devices were fed into another set of computers, where it was stored until analysts retrieved it for study. The combination of mechanical inflow devices, measurement instruments, and computer control programs gave WES and the Baltimore District the ability to recreate any combination of conditions they wished in their miniature Chesapeake Bay and to simultaneously record their effects.

The old method of learning how the Bay behaved was to get out in boats and take measurements over weeks, months or even years on the 4,400-square mile body of water. The model obviously offered a far easier and less-expensive alternative. The fact that the measurements on the model could all be taken at the same time was even more valuable. The cost of taking measurements in the Bay itself was expensive, but the idea of taking hundreds of readings in the Bay at the same day and hour (presumably with hundreds of boats, crews and measuring devices) was next to impossible. Finally, the only way to learn the effects of natural or man-made events on the Bay itself was to wait for such an event to occur and then rush out with boats and instruments to measure it. On the Bay Hydraulic Model many such events could be created by the computer-controlled devices and simultaneously measured by the sensing instruments. Today numerical models are capable of doing almost everything that the Bay Hydraulic Model could do, but such was not the case back in the 1960s and 1970s. This was the rationale for spending several million dollars on a hydraulic model, and the results were impressive.

For some time before the final release of the *Future Conditions Report* in 1977, the Baltimore District had been working with WES's Chesapeake Bay Model Branch at Kent Island and the Bay Study Advisory Group to analyze the findings of the existing and future conditions reports and decide which of the Bay's problem areas should be selected for detailed examination in the final phase of the study. The criteria for selection had been developed by the Baltimore District at the outset of the study. The problems selected should: 1) be of high priority and have Bay-wide significance, 2) maximize use of the Chesapeake Bay Hydraulic Model, 3) avoid duplication of work being conducted under other existing or proposed programs, and 4) be responsive to Congress' original intent in the authorizing legislation.[27]

There were, of course, many problem areas on the Bay and its tributaries identified and discussed in the existing and future conditions reports. When broken into more manageable parts, they amounted to several hundred separate, but related issues. When the Corps and its advisors drew up the list of problems that could be examined by the Bay Hydraulic Model, 51 separate tests were suggested—far more than could be carried out within the time and funding constraints. There were, of course, even larger numbers of Bay-related problems which had become apparent during the first two phases of the study that needed to be assessed to determine if they should be discussed in the final report. After careful consideration in light of the aforementioned criteria, two major areas were selected for more thorough study in the final phase. These were low freshwater inflow into the Bay and tidal flooding.[28] A third area which was clearly identified but could not be addressed during the final phase of the Bay Study was the development of a numerical model that could eventually replace and improve upon the existing Bay Hydraulic Model. In spite of its great value to researchers, the hydraulic model proved to be very expensive to maintain and operate, so once numerical modeling advanced to the place where a Bay numerical model appeared feasible, the hydraulic model could be shut down. This occurred in 1984.

Low Freshwater Inflow Study

The first long series of tests for the final phase of the Bay Study to be run on the hydraulic model examined low freshwater inflow. Low freshwater inflow affected almost all parts of the Bay, and had major ecological, economic and social impacts. The basic cause of low freshwater inflows were long-term droughts in the Bay watershed, but the impact of future droughts would be more severe because human withdrawals of water from Bay rivers, already substantial, would increase. The total water supply demand in the Chesapeake Basin was 4370 million gallons per day (mgd) in 1965, and the Corps estimated that it would increase to 5990 mgd by the year 2020. A portion of the water withdrawn from a river is returned to it, but much of it is lost. This "consumptive loss," as it is called, will be 2060 mgd by the year 2020. This would amount to as much as 11% of the total average flow of the Bay's rivers during a normal rainfall period. During a drought such as those already recorded in the past in the Bay watershed, consumptive losses could amount to 57% of the lowest average monthly inflows! Much of this would occur on the Susquehanna River, which provides over 85% of the freshwater inflow above the Patapsco and 50% of the total Bay inflow. During months of most severe drought in 2020, consumptive loss would account for over half of the Susquehanna's flow.[29]

The primary impact of freshwater reduction is increasing salinity in the Bay and the tidal portions of

Decreases in freshwater inflow changes Bay salinity between present and future drought conditions. Red area shows increased area having a salinity of 5 ppt at a 10-foot depth. Dark blue area shows 15 ppt at the same depth.

its tributaries. These changes, which occur seasonally under average freshwater inflow conditions, would become far more pronounced during droughts and even more severe when man-made consumptive losses of the magnitude projected by 2020 are calculated. The exact nature of these salinity changes on the Bay and the tidal portions of its rivers needed to be ascertained. David F. Bastian, an engineer from WES, and the team of technicians (also from WES) ran a series of tests on the hydraulic model to map salinity levels in the Bay during normal conditions, drought conditions and drought plus consumptive loss conditions. Salinity was measured both horizontally and vertically. Over 500,000 discrete salinity samples were collected during the course of the Low Freshwater Inflow Test Series. Researchers produced isohaline maps of the Bay that indicated salinity levels on the water surface and at 10-foot and 20-foot depths as well as maps showing longitudinal profiles or cross sections.[30] It was no surprise that the Bay became significantly saltier when the freshwater flow from its tributaries slackened, but the model was able to show how this occurred over the course of an entire year and again over the course of an entire drought episode—day by day. It also showed that the magnitude and structural variations in salinity as a result of freshwater losses are dependent on specific hydrodynamic characteristics of each sub-region of the Bay and its proximity to tributaries and the ocean.

The next step was to assess the effects of increased salinity on the biota of the Bay (and the Chesapeake region's human beings can be counted among the 2700 Bay-dependent creatures). There was not enough time or funds to evaluate all species, so the Corps contracted with the Fish and Wildlife Service and a private contractor, Western Eco-System Technology (WESTECH), to identify 57 species that would be representative of the larger group. The potential habitat for the 57 species was mapped for each of the four different freshwater inflow conditions simulated on the Bay Model. With this information, a Biota Evaluation Panel, formed by the Fish and Wildlife Service, determined how the changes in habitat would affect each of the selected species. The panel found that a few species would thrive in the saltier waters, but the great majority would be adversely affected. The more mobile finfish populations suffered varying degrees of stress, but the really severe impact fell on shellfish that could not remove themselves. Oysters and soft clams would be devastated. This in turn would result in economic losses of $25 million to $30 million per year to the Bay's commercial fishing industry.[31]

Supplementing the flow of fresh water on the Bay's tributaries during periods of drought could be accomplished by water conservation and/or increased reservoir storage capacity. Water conservation was judged to be of some value, yet even the most optimistic projections of this possibility would produce only a modest improvement. The construction of new reservoirs to augment the Bay's freshwater supply was not economically justifiable, but increasing the capacity of existing reservoirs or managing existing capacities in a different manner could have a significant positive impact at much lower cost. The most promising river basins in this regard, were the Susquehanna, Potomac, Rappahannock, and James; but there needed to be a far more detailed analysis of the many issues surrounding these alternatives than could be accomplished in this phase of the Bay Study before any specific projects could be recommended. As a first step, however, it was recommended that existing water supply sources be given more detailed study to determine the benefits and costs of reallocation alternatives.

In view of the adverse environmental and economic effects of low freshwater inflows into the Bay, the Corps examined a lengthy list of actions that might be taken to lessen negative impacts on the Bay's biota and settled on two actions: first to attempt to supplement low flows on certain of the Bay's rivers; second, to deal directly with the Bay biota. The first set of possible actions focused on the protection and restoration of the commercially valuable shellfish and finfish populations in the Bay during and after a drought. Tests run on the Bay Hydraulic Model showed that it takes the Bay only six to nine months of average inflows to recover to a state of dynamic normalcy following a drought. Therefore, the possibility exists for a well-timed program of seafood catch limitations followed by shellfish restoration and finfish restocking to reinstate commercial seafood supplies more rapidly than would occur naturally.[32] The economic and ecological feasibility of this set of alternatives required more detailed analysis and would come under the authority of the Fish and Wildlife Service, the National Marine Fisheries Service and state natural resource agencies.

The second set of alternatives dealt with the regulation of freshwater inflows to lessen biota damage. This clearly fell within the traditional role and authority of the Corps as the builder and operator of multipurpose reservoirs in the Chesapeake Basin. The pioneering work done by the Corps on the metropolitan Washington area water supply problem between 1975 and 1979 proved that even with a relatively small increase in reservoir capacity, a computer-aided drought management program could allocate Potomac Basin

water supplies in a manner that would meet the needs of the Washington DC area and still provide a minimum flow into the Potomac estuary.[33] This project will be discussed in more detail in Chapter VI. Its success in regard to the problem of low freshwater inflows into the Potomac estuary provides an optimistic portent for other rivers—especially the Susquehanna. The recommendations of the District Engineer in the Bay study *Final Report* included the recommendation to conduct "a comprehensive water supply and drought management study that will identify those measures required to optimize the use of existing water supplies in the Bay drainage basin, and minimize reductions in freshwater inflow into the Bay."[34]

Increasing the capacity of existing reservoirs could positively impact low flows at a lower cost than constructing new reservoirs to augment the Bay's freshwater supply. The most promising river basins in this regard were the Susquehanna, Potomac (below), Rappahannock and James.

Tidal Flooding

The last series of investigations conducted as part of the Bay study dealt with the periodic threat of tidal flooding. Tidal flooding has been a problem for shore communities around the Chesapeake Bay since the 18th century and has caused significant damage.[35] Since the late 1800s approximately 100 hurricanes and "northeasters," have moved through the Bay. The hurricane of 1933 caused over $100 million in damages and the northeaster of March 1962 caused $54 million

in damages (1983 dollars).[36] Neither of these storms was among the worst to hit the Bay since its settlement, but they still managed to inflict great damage. The potential losses from a storm like those that occurred in 1933 and 1962 would be much larger today because the tidal flood plain has become much more intensely developed.

Prior to 1965 there was no comprehensive knowledge of exactly where the tidal flood plain lay. This was the first major task for the Corps officials conducting this section of the Bay study. The Corps, in cooperation with the National Weather Service, determined what is called the Standard Project Tidal Flood for the Chesapeake Bay. This was defined as "the largest tidal flood that is likely to occur under the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographic region." This storm would raise the average tidal level 13 feet above normal with waves averaging five feet on top of the tide, so the total increase in water levels would reach 18 feet above normal.[37] Such a gigantic storm would have to strike the Bay at just the right (or wrong) speed and angle during one of the periods of maximum natural high tides to produce flooding to a depth of 18 feet above mean sea level. If that were to happen, several hundred thousand acres of land would be flooded. In the 60 already settled and built-up towns of the Bay, 82,000 acres of developed land would be inundated. A much more likely storm, which the Corps defined as the 100-year storm, would raise water levels 6-11 feet and flood approximately 27,000 acres of developed land in 32 waterside communities. The problem will become more serious as the Bay's waterside communities are more intensely developed. The Corps estimated that future construction on the tidal floodplain will increase the area of developed land subject to flooding by an additional 58,000 acres for the maximum flood and by 19,000 acres for the 100-year flood.[38]

The protection of small clusters of structures or individual buildings scattered along several thousand miles of shoreline is not economically feasible and no attempt was made to investigate structural solutions for these areas. More densely populated towns,

In Crisfield, Maryland, tidal flooding is a problem as it has been for shore communities around the Chesapeake Bay since the 18th century.

however, looked promising. The Corps investigated 60 waterside communities, 46 in Maryland and 15 in Virginia, and selected 15 for detailed study (7 in Maryland and 8 in Virginia). Each of the selected communities was first examined to learn the magnitude and frequency of tidal flood surges. Calculations were made to determine the amount of damage that would be caused by various stages (heights) of tidal surge in each community. Preliminary work was also done to develop Bay-wide stage-frequency relationships with a numerical model, but there was insufficient funding to complete this aspect of the investigation. Nevertheless, the stage-frequency data were collected and analyzed for each of the selected communities, and served as the basis for assessing the cost effectiveness of alternative flood protection plans.[39]

A broad range of structural and non-structural measures were evaluated in various combinations to gain maximum cost-effectiveness and environmental quality. In some cases five to eight different combinations of structural and non-structural elements were designed. Rock Hall, Maryland, for example, was given 10 different choices. While only three of the fifteen communities selected for detailed study were found to have flood protection plans with a favorable benefit/cost ratio, the more accurate analysis of their potential flood problem was very useful to state and local governments in planning local flood warning systems and developing local zoning procedures to restrict or regulate development on the tidal flood plain.

The *Final Report* of the study included the recommendation that Congress consider additional funding to complete the numerical model capable of forecasting tidal flood stages and stage-frequency relationships. It was also recommended that Congress support local efforts to develop flood warning systems, evacuation plans and floodplain management programs in the Bay's shoreline communities.[40] In 1985, the state of Maryland requested that a hurricane evacuation plan be developed for its portion of the Chesapeake Bay. This plan is now being prepared by the Corps' Baltimore District office in cooperation with the Federal Emergency Management Agency, the National Weather Service and several agencies within the Maryland state government. The hurricane evacuation study and plan will cost $556,200 and will be completed in June 1989.[41]

Bay Study Final Report

The issuance of the *Chesapeake Bay Study Final Report* in September 1984, containing the final conclusions and the recommendations of the Baltimore District Engineer, brought a close to the Chesapeake Bay Study. But in another sense, it simply closed the first chapter of the Corps' broadened involvement in the federal-state Chesapeake Bay Program. In particular, the study led to a Senate resolution authorizing further shoreline erosion studies, an authorization to expand the study of low-flow reallocation on the Susquehanna River, and the program to develop, with the EPA, a numerical model of the Bay. In a more general way, the Corps' Chesapeake Bay Study, along with the 1983 EPA study of Bay water quality problems, underlined the necessity for the type of comprehensive approach envisioned by the signatories of the Chesapeake Bay Agreement in December 1983. The Chesapeake Bay Study was clearly a landmark program for the Baltimore District and the Corps of Engineers. Not only did it provide the larger community with a conceptual framework and a body of data that has substantially advanced their understanding of the Chesapeake Bay region, it helped create within the Baltimore District Office of the Corps one of the major centers of Chesapeake Bay expertise. The formal entrance of the Corps of Engineers into the Chesapeake Bay Program in the fall of 1984 was the natural culmination of its 17-year Bay Study program. The knowledge the Corps had generated, and the experience it had gained in conducting this vast study, constitute a major contribution to the Chesapeake restoration and protection program.

Chapter IV
Navigation Channel Dredging And The Bay Environment

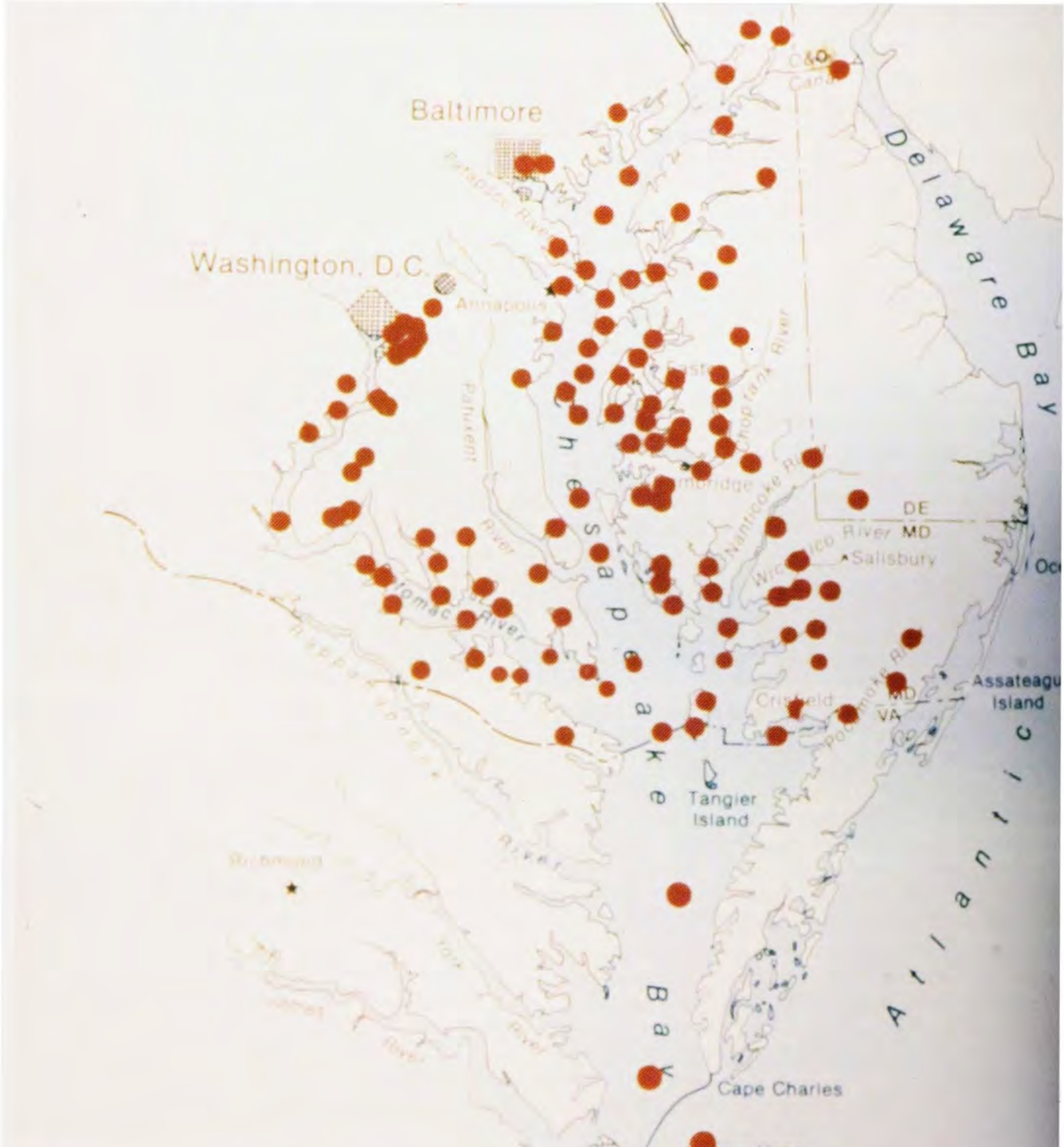
As indicated previously, a significant proportion of the economic activity of the Chesapeake region is dependent on maritime trade. The volume of this trade, and the size of the vessels that carry it, will continue to grow in the coming decades so the Bay's navigation channels will need to be well maintained. The Baltimore District's *Future Conditions Report* projected the foreign, coastwise and internal waterborne commerce of the Chesapeake Bay ports. As expected, the ports of Baltimore and Hampton Roads which accounted for over 80% of the entire tonnage of cargo shipping in the Bay, would gain an even larger share of that trade by 2020. Corps projections indicated that Baltimore would continue to be an important bulk port, with the shipping of petroleum, ore and coal, increasing from 30.3 million short tons (mst) in 1972 to 58.4 mst in 2020. More dramatically, general cargo trade was expected to increase very substantially, from 6.7 mst to 29.6 mst. Most of Baltimore's trade will move through the Baltimore Harbor Channel and out through the Virginia capes, but by 2020 about 17% of it will move through the Chesapeake and Delaware Canal, which has a depth of 35 feet and can accommodate ships of over 800 feet. Thus the maritime trade of the Port of Baltimore will continue to grow and will be dependent on its more than 100 miles of dredged channels.[1]

Hampton Roads at the south end of the Bay was a major bulk cargo port in the 1970s with 47.0 mst of bulk cargo, of which 63% was coal exports. Its bulk trade was projected to rise to 83.2 mst by 2020 with coal accouting for 67% of the total. The future commerce moving through Hampton Roads becomes significantly greater if the waterborne commerce of the James River is included. The great majority of James River commerce, which will amount to 17.4 mst by 2020, will be petroleum moving in and out of the largest oil refinery in the Chesapeake Bay region near the mouth of the James River at Yorktown. The Corps estimated the general cargo trade at Hampton Roads to increase by a factor of 5, but it was not very large in 1972 (only 2.6 mst) and therefore the total expected by the year 2020 is 14.6 mst, or about half the amount expected in the Port of Baltimore. The only other major shipping facility on the Bay is the Steuart Petroleum Refinery at Piney Point, Maryland on the Potomac River 13 miles above its confluence with the Bay. Steuart Petroleum estimates that shipping in and out of this refinery will reach 13.3 mst by 2020, but given the unstable nature of the international oil industry, projections can change significantly. The movement of bulk petroleum on the James, Rappahannock, Wicomico, Nanticoke and Choptank Rivers is much smaller, but is still of local importance.[2]

The use of the Chesapeake as one of the nation's and the world's major commercial waterways is a vital part of the Bay region economy. A total of 118,000 jobs depend on the ports of Baltimore and Hampton Roads.[3] This intensive use of the Bay's navigational potential creates a number of problems that require careful thought and action. The Chesapeake Bay Study examined a long list of issues related to Bay navigation. The great majority of these problem areas had been studied previously by the Baltimore or Norfolk Districts as discreet issues. This was the first time the problems had been analyzed as a unit, and the result was a comprehensive picture of the impacts of navigation on the Bay. The *Future Conditions Report* provided the most detailed discussion of these problems and they were reiterated in the *Final Report*. Six navigation-related problem areas were determined to be of the highest priority. These were: 1) the safe accommodation of larger, deeper draft bulk cargo vessels which were expected to dominate world trade and will require deeper channels in the Chesapeake Bay, 2) finding the most economically and environmentally acceptable methods of dredged material disposal, particularly for the deep channels leading to the Bay's two major ports, 3) alleviation of potential maritime traffic congestion in ports, channels and anchorage areas to minimize the possibility of accidents with the potential for the spilling of hazardous substances, 4) minimization of the growing potential for conflicts between commercial and recreational users of the Bay, 5) reduction of shoreline erosion in areas close to navigation channels where waves from passing vessels were suspected to contribute to the damage, and 6) examination of the most economical and environmentally sound ways to provide additional land to accommodate port facility expansion.[4]

In the recommendations of the District Engineer at the conclusion of the Chesapeake Bay Study, the disposal of dredged material was singled out for further action by the Corps since it is clearly the largest and most vexing issue. The question of channel depths was resolved, at least for the immediate future, during the final phase of the Bay Study by the creation of the Hart-Miller dredged disposal site near Baltimore,

The Corps of Engineers has many navigation projects on the Chesapeake Bay.



which will receive all the dredged material from the construction of the approach channels of the Baltimore Harbor 50-foot Channel Project. This disposal area will be sufficient for the construction phase of the Baltimore 50-foot channel; but the question of how to dispose of maintenance dredging material through the years to come, was *not* solved, because the Hart-Miller Disposal Site will become filled to capacity long before 2020. Maintenance dredging from the Bay's other navigation channels poses smaller but still serious disposal problems. For this reason, the District Engineer recommended in the Bay Study *Final Report,* that Congress authorize the Corps to conduct, ''a comprehensive Bay-wide study to develop plans for dredged material disposal for the maintenance and improvement of all major harbors and approach channels...''.[5] Congress has not yet authorized such a study.

Except for shoreline erosion, solutions to the remaining problems lay with agencies outside the Corps of Engineers. However if the expansion of port facilities is to be solved by creating new land out from the present shoreline, such action would involve the Corps of Engineers Regulatory Branch for the issuance of a ''404'' permit.

The disposal of dredged material is one of the Baltimore District's inescapable problems. The district is responsible for all dredging projects in the Maryland

The Chesapeake, one of the nation's and the world's major commerical waterways, is a vital part of Bay region economy.

portion of the Chesapeake Bay. It is directly responsible for 120 federally-authorized projects. If these channels are not regularly dredged, they will become filled and shipping will cease, resulting in the loss of millions of dollars. Its Regulatory Branch must also approve all applications for state, local, and private dredge and fill permits. The hundreds of small private channels are also important, and their collective impact on the Bay economy is significant. The amount of material dredged in the Chesapeake is very large. Between 1970 and 1980 the Baltimore District dredged 10,899,744 cu. yd. of material from its federal projects, and the Norfolk District dredged 52,994,428 cu. yd. Between 1975 and 1980 the Baltimore and the Norfolk districts issued a combined total of 1,002 permits for private dredging projects which totaled 12,153,619 cu. yd. in the Baltimore District and 15,202,677 in the Norfolk District. The great majority of dredging, in terms of the volume of dredged material, is generated by a relatively few very large projects. In the Baltimore District there were 35 federal navigation projects in the Chesapeake Bay on which dredging occurred in the 1970-1980 period. Seventy-one percent of all dredged material from these projects came from the Baltimore Harbor channels, 10% from four other large projects, and only 19% came from the remaining 29 projects.[6]

Baltimore's Inner Harbor is one of the more than 400 ports and harbors in the United States for which the Corps of Engineers has responsibility.

The pace of dredging in the Baltimore District increased significantly during the first half of the 1980s, with an annual dredging rate of 3.2 million cu. yd. compared to the approximately one million cu. yd. rate during the 1970s. Over 90% of the 1980-1985 dredging came from maintenance of the Baltimore channels. The commencement of the 50-foot channel deepening in 1987 has increased the figure dramatically, since the project calls for the removal of 52 million cu. yd. of dredged material by the end of the decade.

There are some environmental problems connected with the actual process of dredging, particularly during periods when marine species are spawning or otherwise vulnerable to higher levels of turbidity; but the major problem is the disposal of the dredged materials, especially if they are contaminated with chemical dumpings or heavy metals that do not deteriorate. This is a very serious problem in Baltimore Harbor and several other areas of the Chesapeake Bay, and in hundreds of other national waterways. The Corps is responsible for the operation and maintenance of over 400 ports and harbors in the United States and over 25,000 miles of navigable waterways. Passage of the Water Resources Development Act of 1986 caused a major increase in dredging activity in the Chesapeake Bay and many other areas of the nation. Maj. Gen. Henry J. Hatch, director of Civil Works, U.S. Army Corps of Engineers, recently estimated that during the next 10 years the total amount of material to be dredged from the nation's waterways may approach a billion cubic yards.[7] Such an amount if deposited in the District of Columbia, would bury the entire 72-square mile area under 14 feet of sand, silt and gravel.

The Dredged Material Research Program

As stated earlier, for many decades dredged material was disposed of overboard along the sides of the navigation channel or on adjacent shore areas to the channel. Dredged material, regardless of its composition, was called "spoil," a term that applied more accurately to the manner in which it was disposed of than to its intrinsic value as a resource. Relatively little thought was given to the environmental effects of dredging and the indiscriminate disposal of dredged materials until the 1950s and 1960s. By 1960 the Corps as a whole, and the Baltimore District as well, began to give a great deal of attention to the problem, but were hampered by a lack of basic scientific research on the subject. Congress recognized the problem and included in the 1970 River and Harbor Act (Public Law 91-611), Section 123(i), which authorized the Corps to conduct a nation-wide research program on the environmental effects of dredged material disposal. Since 1970, the Corps has expended almost $100 million for research and development on dredged material disposal.[8] The initial research program, one of the largest research efforts ever conducted by the Corps, was called the Dredged Material Research Program (DMRP). It was conducted between 1973 and 1978 by the Corps' Waterways Experiment Station with the aid of several other federal agencies, 47 commercial scientific research firms and 37 universities or university-affiliated institutes. The DMRP also drew on the knowledge and experience of Corps officials from the Chief of Engineers' Office and from a number of the Corps districts, including personnel from Baltimore. The DMRP produced more than 250 individual research reports based on laboratory and field studies on Corps dredging projects.[9]

The DMRP provided the Baltimore District with a wealth of information that facilitated its efforts to dispose of dredged material in an environmentally satisfactory manner. One major conclusion of the research was that the great majority of dredged material (about 90%) is not contaminated and, if disposed of according to a carefully designed program, will not significantly affect the local environment in an adverse way. In some situations, dredged materials can be used to create fish or wildlife habitat or restore one that had been lost. Other dredged materials, sand for example, can be used for an even wider variety of useful purposes and is a valuable resource. One dredging company recently offered to dredge part of the Baltimore Harbor Approach Channel free of charge, if it could keep the sand it dredged from the bottom.[10]

Two fundamental conclusions of the DMRP have great significance for the Baltimore District, and those concerned with dredging in the Bay. First, DMRP's directors found there was "no single disposal alternative that presumptively is suitable for a region or group of projects." Each project must be individually evaluated to determine the most environmentally-sound dredging and disposal program. The second basic conclusion was that regions having a number of dredging projects must develop a long-term coordinated disposal plan for all current and future dredging. The final report of the DMRP stated: "No longer can disposal alternatives be planned independently for each dredging operation... While each project may require a different specific solution, the interrelationships must be evaluated from a holistic perspective..."[11]

The Baltimore District gradually came to recognize the need for a coordinated dredged material disposal program. Both the 1961 Bay survey and the 1977

Future Conditions Report identified this issue. The recommendations of the District Engineer at the conclusion of the Chesapeake Bay Study called for a long-term disposal study. The Environmental Protection Agency has asked repeatedly that such a study be funded, and it was also recommended by the area governors at the 1980 Chesapeake Bay Conference. In December 1984, the six senators from Maryland, Pennsylvania and Virginia sent a letter to the Secretary of the Army requesting funds for the study, but so far it has not been included in the President's budget request. The urgency of this problem has been underlined by the commencement of dredging for the Baltimore 50-foot channel, which will just about fill the Hart-Miller disposal site. The 50-foot channel for Baltimore is the largest single dredging project ever undertaken in the Bay, but it is only part of a much larger total dredging program foreseen during the next 30 years. The most recent estimates of the Maryland Department of Natural Resources and the Virginia Port Authority estimate that between 1987 and 2020, disposal sites will be needed for approximately 550 million cu. yd. of dredged material from the navigation channels of the Chesapeake Bay. The Baltimore District has plans ready for an 18-month reconnaissance study of this long-term disposal problem if funds become available.[12]

The long delay in starting the Bay-wide disposal site study has been unfortunate, but one positive consequence is that during the last 15 years the Corps has gained knowledge and practical field experience in dredging and the disposal of dredged materials. The development of innovative dredging and disposal techniques in the Baltimore District falls into three phases. The first phase focused on the district's growing awareness of the environmental issues surrounding the deepening of the Chesapeake and Delaware Canal and its Chesapeake Bay approaches in the 1960s. The second phase involved the long searching debate over the Baltimore Harbor 50-foot channel and the Hart-Miller disposal site, a controversy that spanned the whole period from 1970 to 1986. The third phase concerns the district's smaller dredging projects which allowed it to experiment with an increasing variety of new beneficial uses of dredged material in the Bay—an activity that began in the 1970s and has grown to maturity in the 1980s.

The Chesapeake And Delaware Canal Approach Channels

The controversy over dredged material disposal from the C & D Canal illustrates the growth of environmental considerations and its gradual impact on Corps plans in this fragile and sensitive area of the Bay. The upper Bay is to a large degree the "nursery" for many species of fish that spawn there each year, so the state of Maryland has been very cautious about dredged material disposal in this region. Its local residents have been represented for many years by an influential citizens association. The combined pressure of the state government and local residents caused the Philadelphia and Baltimore districts to revise their thinking about dredged material disposal in the upper Bay during the 1960s; but it is also apparent the Corps was becoming increasingly amenable to solutions that were less cost-effective, but provided greater environmental protection.

The C & D Canal links the Delaware River with the upper end of Chesapeake Bay, cutting 100 miles off the voyage between Baltimore and Europe or the Middle East.

The C & D Canal links the Delaware River with the upper end of Chesapeake Bay across an 18-mile neck of land, cutting 100 miles off the voyage between Baltimore and Europe or the Middle East. It is one of the busiest canals in the world. Built by a private company between 1824 and 1828, the C & D was purchased by the federal government in 1919. The Corps of Engineers converted it into a sea-level canal 12 feet deep and 90 feet wide. In 1938, it was enlarged to 17 feet deep and 250-400 feet wide. The approach channel was also enlarged and extended to a total length of 26 miles out into the Chesapeake Bay. During these operations the Philadelphia District of the Corps of Engineers, which is responsible for the canal and its approaches, dredged over 75 million cu. yd. of material which was disposed of in the waters of the upper Bay. In addition, between 1932 and 1962, another 30 million cu. yd. of maintenance dredged materials were also deposited in the upper Bay. Very little attention was given to the environmental affects of this enormous disposal program.[13]

The increasing size of vessels seeking to use the canal led Congress in 1954 to authorize a channel depth of 35 feet and a width of 450 feet. The channel enlargement required the disposal of over 19 million cu. yd. of dredged material. This time the Philadelphia District gave careful attention to the disposal question. Five alternative disposal plans were examined with various combinations of upland, man-made island, and overboard disposal sites. The recommended plan provided for the disposal of 10 million cu. yd. on a land site adjacent to the mouth of the Elk River, with

the remaining 9 million cu. yd. to be pumped directly into the Bay along a 10.7-mile strip running parallel to the channel from the mouth of the Sassafras River to the north end of Poole's Island. This same disposal area would be used for an additional 15 million cu. yd. of maintenance dredging over the next 50 years. Alternatives calling for more distant removal of the spoil to land sites or more remote water sites were far more expensive. The significantly lower cost was the major reason for adopting the overboard disposal plan.[14]

This alternative, however, appeared to some people in the upper Bay area to pose a serious menace. The state of Maryland and the U.S. Fish and Wildlife Service also objected because they feared its effects on the aquatic life of the generally shallow upper Bay. A series of meetings between the planners in the Philadelphia District of the Corps, the Fish and Wildlife Service and the state of Maryland during 1963 failed to resolve the issue. The Corps contracted with three marine biologists outside the government to assess the effect of their disposal plan. The biologists' report in 1964 concluded that the dumping of spoil into marshes, wetlands or other very shallow and fragile locations would be destructive, but the Corps' plan to dump it into deeper areas of the Bay alongside of the C & D channel "would be a harmless operation..." One of the three authors argued that dredging would probably have a beneficial effect on this area's aquatic life.[15]

The U.S. Fish and Wildlife Service, the state of Maryland and Bay watermen associations remained unconvinced. The state of Maryland proposed disposing of the dredged material in a diked area of Aberdeen Proving Ground used for testing military weapons, but the Philadelphia District rejected the plan because of the increased cost and the danger to men and machinery in an area containing unexploded shells and rockets. Other proposals involved removal of the dredged material to several distant areas, but were too costly compared to the Corps' plan of hydraulic dredging and direct disposal in areas immediately adjacent to the channel.[16]

In 1965, the Philadelphia District Engineer and other members of the Philadelphia and Baltimore districts met with Governor Millard Tawes of Maryland and other state officials to present the Corps' case directly. They were countered by Roy Walsh of Easton, Maryland, a member of the Maryland State Board of Natural Resources, who said the Corps was placing, "too much emphasis...on the cost of the alternate schemes and not on the long range effect...."[17] The state asked the Corps to consider several other areas for disposal—five on the Eastern Shore of the upper Bay and one in a deep trench off Poole's Island. The Corps said these plans were more costly, but agreed to study them.[18]

Shortly thereafter, Senator Daniel Brewster of Maryland requested that the Corps' Committee on Tidal Hydraulics review the proposal because he was deeply concerned over the effects of the disposal plan on the marine life and beaches of the upper Bay. The Committee on Tidal Hydraulics took a very narrow legalistic view of the issue. Its report presented all the concerns of those opposed to the overboard disposal plan, but stated that opponents had, "not yet been able to present a case proving beyond all reasonable doubt that the overboard dumping of dredged spoil will increase the turbidity of the water to a harmful degree."[19] The committee stated that it could not learn whether past overboard disposal had contributed significantly to turbidity or salinity changes in the upper Bay. It also admitted that the ultimate impact of the current dredging disposal plan on the Bay could not be predicted because "knowledge of the regimen of the Chesapeake Bay is not sufficient" for accurate predictions.

> ...the material deposited overboard could remain in place, or some or all of it could leave the disposal area, increase the turbidiy of the water to an extent dependent upon the rapidity with which it is removed, and ultimately deposit it elsewhere. The "biological" injury that such increased turbidity, if any, and the sedimentation, if any, would do is beyond the purview of the Committee, and there is a great difference of opinion among the biologists. It follows that it is advisable to proceed cautiously with large-scale overboard disposal operations until additional knowledge has been obtained.[20]

The committee recommended that an initial 1.7 million cu. yd. of spoil be deposited overboard only during the period from October to February to avoid the time when fish spawning, egg hatching, and juvenile fish inhabitation occur, and then have the area studied by marine biologists to determine its effect on aquatic life. This would allow a more informed judgment to be made on subsequent disposal plans.[21]

The Corps accepted the proposal and transferred funds to the U.S. Bureau of Sport Fisheries of the Fish and Wildlife Service, which contracted with the University of Maryland Chesapeake Biological Laboratory (CBL) and the Johns Hopkins University Chesapeake Bay Institute to determine the effects of the 1.7 million cu. yd. overboard disposal project on the upper Bay and provide a background for future studies of the entire relationship between the C & D Canal and the local aquatic environment. The CBL

conducted field studies at the disposal site in 1965-1966. Its 1967 report convinced the Maryland Board of Public Works that the suggested method of spoil disposal, "was not likely to cause sufficient gross damage to warrant objection," but it strongly recommended continued close monitoring of future disposal activities. It also recommended development of data to determine the effects of turbidity on the area's major aquatic species. Subsequent studies of this question tended to confirm the conclusions reached in 1967. The dredging program for the 35-foot channel was completed in 1975, and monitoring of the area continued until 1981. No significant change in the ecology of the upper Bay has become evident as a result of dredging.[22] The research and monitoring the Corps finally agreed to do in 1965 for the C & D Canal approach channels is now done, as a matter of course, on all dredging projects.

As the canal enlargement neared completion in 1970, upper Bay area residents began to fear that it would alter the flow of water between the Delaware and Chesapeake Bay and harm the upper Bay. Subsequent research showed no significant hydrological, ecological or biological impact of the altered flow of water through the enlarged canal, but this was not well understood in 1970. Concern centered on the anticipated increase in the net flow of water out of upper Bay into the Delaware River estuary. Residents feared this would increase salinity levels in the upper Bay, altering its marine life and rendering the area unsuitable as a water supply source.[23]

In February 1970, Maryland Congressman Gilbert Gude complained to the Chief of Engineers Office that the Corps was not giving sufficient attention to the potentially harmful effects of the canal enlargement on the upper Bay. Armed with information from a group of marine scientists at the Johns Hopkins University, Gude issued a press statement warning that the enlargement will bring much greater exchanges of water between Chesapeake and Delaware bays which could result in an "environmental disaster" for the upper Bay.[24]

Congressman Rogers C. B. Morton joined Gude in requesting a formal hearing before the House Committee on Public Works to require from the Corps a feasibility study to determine whether some type of barrier should be built into the canal to reduce the volume of water moving through it during periods of high tides and winds in the Chesapeake Bay. At the hearing, held in April 1970, Brigadier General Richard H. Groves, Deputy Director of Civil Works for the Corps, testified that previous studies of the upper Bay showed no ill effects of water exchanges through the canal; but that in response to Congressman Gude's concerns, the Waterways Experiment Station in Vicksburg was going to run tests on a numerical model of the enlarged canal to determine the exact volume of water exchanges under a variety of possible tidal and wind conditions. If this study and other investigations indicated serious negative impacts on the upper Bay, the Corps would seek to install some type of device in the canal to reduce water exchanges to an acceptable level. He suggested that these studies could be done fairly quickly, before scheduled completion of the enlargement project, and pledged that the Corps would not put the enlarged portion of the canal into operation until the issue was resolved. He did not think, however, that the work on the project should be held up pending the completion of these investigations.

A group of marine biologists, fish and wild life experts, and water quality scientists from the Department of the Interior disagreed with General Groves. Dr. Leslie Glasgow, a fish and wildlife specialist, spoke for the group expressing grave concern over the impact of enlargement on the aquatic life of the upper Bay. He recommended that work on the canal be halted until better information could be obtained. This view was not supported by the two major scientific witnesses from academic institutions, Dr. Donald W. Pritchard from Johns Hopkins and Dr. L. Eugene Cronin of the University of Maryland. They essentially agreed with General Groves that the WES study, coupled with more detailed investigations of potential impacts of the water exchanges on marine life, could be carried on simultaneously with construction of the canal project. Dr. Pritchard testified that his own research led him to think the enlargement would probably not have a significant effect on the upper Bay, but that further detailed studies should be conducted. The views of these two scientists convinced the committee to recommend continuation of the enlargement project while at the same time directing the Corps to carry out studies of its impact on the upper Bay.[25] This is the course of action followed by the Corps during the next three years.

The Philadelphia District's 1973 EIS on the canal widening contained the major conclusions of the WES studies and the interium conclusions from the more detailed investigations by Johns Hopkins, the University of Maryland and the University of Delaware. By this time the project was 88% completed; but the question of freshwater exchange in the canal was now, at least, reasonably well studied. Tests run in 1970-1971 by the Waterways Experiment Station on hydraulic and numerical models of the canal and adjacent portions of the Delaware and Elk rivers indicated that during certain seasons there would be as much as a

780% increase in the short-term net flow of water from the Chesapeake into the Delaware River, but the average net outflow from the Bay would increase by only 2000-3000 cubic feet per seconds (cfs). The degree to which this altered-flow pattern would change salinity or marine life in the upper Bay could not be determined by the WES tests, since the model included only a small portion of the upper Bay.[26]

The impact of these possible exchanges of water through the canal was studied in 1972-1973 by the marine institutes of the University of Maryland, Johns Hopkins University and the University of Delaware under a Corps contract. The joint report of the institutes, issued in 1973 at the same time as the Corps' EIS, concluded that no drastic changes in salinity or marine life would result from widening the canal, though under certain seasonal or extraordinary natural conditions, there would be significant short-term changes. Longer-term effects could not be predicted with equal confidence and required continued monitoring.[27] The report stated that installation of flow-control devices in the canal, which had been suggested by the Corps and strongly endorsed by the EPA as a means of counteracting the changes that might occur as a result of the canal enlargement, "might be advantageous when there is a threat of exceptional eastward transport of fish eggs and larva." Yet even the use of these flow-control devices would always have, "mixed environmental effects," since they would, "create a more un-stable environment than what would be present in post-enlargement conditions."[28] In sum, the joint-institute report predicted no serious immediate effects on local marine life and hydrology, doubted the severe impact even on the longer term, and scarcely guessed at the long range effects of flow-control devices. In the years since the study was conducted, its conclusions have been born out by experience. No short-term changes have occurred since 1973, no longer-term changes have appeared, and the absence of flow-control devices has not yet resulted in any observable environmental changes. Nevertheless, some marine biologists such as Robert Biggs still express concern for the long-term effects of the water exchanges through the canal.[29]

The Baltimore 50-Foot Channel

As noted earlier, the great majority of all dredging in the Chesapeake Bay is connected with the various segments of the Baltimore Navigation Channel. The Port of Baltimore is absolutely dependent upon its dredged channels to keep it competitive with other major ports of the world. Bulk goods and general cargo moving through the port come from as far away as Chicago and Minneapolis and the imports are distributed to an even wider area. While the C & D Canal route is important, the major link between the port and the rest of the world is the channel leading down the Bay and out the Virginia capes. In 1958, Congress authorized the deepening of this channel to 42 feet, and the work was completed by the early 1960s. The great majority of the 172-mile Baltimore Channel is through portions of the Bay that are over 50 feet deep. These require no dredging. There are five sections that do require deepening. They are listed below as they existed prior to the 50-foot deepening.[30]

Channel	Depth (feet)	Width (feet)	Length (miles)
1. Cape Henry	42	1000	1.0
2. York Spit	42	1000	10.4
3. Rappahannock Shoal	42	800	5.3
4. Baltimore Harbor Approach Channels (Craighill & Brewerton)	42	800	19.9
5. Curtis Bay, Middle Branch, NW Branch	35-42	600	5.8

In 1958, when the Baltimore Channel was authorized for 42 feet, the House Committee on Public Works suggested that a greater depth would probably be required, in view of the increasing draft of ocean vessels. The committee asked the Corps to prepare a preliminary report on the subject, and the task was given to the Baltimore District. Not surprisingly, the Maryland Port Authority and the city's leaders urged that a deeper channel be dredged. The Baltimore District looked at the projections for world shipping and trends in ship size, balancing this against the cost and environmental effects of various depths of channel deepening. The Corps determined that a uniform 50-foot channel would be optimal when all aspects of the issue were considered and recommended this size channel be developed from the Virginia capes to Baltimore's outer harbor. District personnel also urged that the Rappahannock Shoal Channel be widened to 1000 feet. The 8-foot increase in depth also meant lengthening the channels, primarily in the Virginia portion of the Bay. The dredged portions of the 50-foot channel system would be lengthened from 44 miles to 57 miles and would require the removal of approximately 66 million cu. yd. of dredged material (32 million in Virginia and 34 million in Maryland).[31]

Public hearings on the proposed channel deepening were held in May 1966 and strong support was voiced by Baltimore business interests and the state of Maryland. There was no opposition to the proposed project at this hearing. Commercial, industrial and governmental officials all agreed on the economic necessity of the project. Congress authorized it in

Section 101 of the Rivers and Harbors Act of 1970. The economic benefit-cost ratio of the project was always favorable and grew even better as Baltimore's trade increased during the 1970s and the 1980s. Even though the total cost of the dredging project increased from $72.7 million in 1969 to $290 million in 1987, the annual benefits increased even more rapidly, so the benefit-cost ratio increased during the same period from 2.0:1 to 4.8:1.[32]

The deepening of the ship channels themselves did not stir significant public controversy since the increase from 42 to 50 feet appeared to constitute no major change in areas already vastly altered for over 100 years; but the extension of the channels into new, largely undisturbed portions of the Bay was more problematical. Questions were raised by scientists and government officials, including some within the Corps of Engineers, over the effect of the proposed deepening and lengthening of the channels on currents and salinity levels.

Deepening the Baltimore Harbor Approach channels north of the Bay Bridge would clearly cause changes in local currents and salinity levels. Almost no one perceived any serious environmental danger from these changes. A test was run on the Chesapeake Bay Hydraulic Model to determine the exact degree of change that would occur. It showed only subtle alterations in current velocity that were judged to be "relatively small." Salinity changes varied from place to place along the channel. In most areas the change was again fairly small, although it would cause several highly saline-sensitive species to alter their distribution in the channel area due to a slightly increased intrusion of salinity into the main estuary.[33]

More significant salinity changes would occur in the Patapsco River. Here, the hydraulic model tests showed noticably higher salinity levels resulting from the proposed channel deepening, 5 ppt. saltier, with penetrations of higher salinity levels farther up the river and greater stratification in the water column.[34] This would, theoretically, lead to more extensive shifts in the distribution of saline-sensitive species, but due to the contaminated sediments in the river, very few such species presently existed there.[35] The comments received from the states of Maryland and Virginia and from concerned federal agencies contained no serious questions regarding the environmental impact of the channel dredging. In fact, no one raised any questions about the actual dredging of the harbor approach channels until 1981, when Chris White, one of the biologists for the Chesapeake Bay Foundation, said he thought there was some chance that a change in current velocity, combined with salinity changes, could increase the amount of contaminated sediments stirred up by the dredging, transporting them out into the open Bay under certain tidal or weather conditions. This view received support from Mitchell A. Granat, a researcher from WES who had authored a report on the channel deepening based on studies on the Bay Hydraulic Model. He was quoted in the newspapers saying that the Corps failed to take note of his report and therefore underestimated the amount of pollution that would move out into the Bay.[36] These opinions did not cause great concern to either the Corps or the state of Maryland because the dredging was to be very closely monitored by the state to assure nothing like this would occur.

Debate over the environmental effects of the channel deepening was a minor chord because there was so little conclusive evidence of significant impacts. It also was drowned out by the long and heated debate over the disposal of the dredged material from Baltimore Harbor and Maryland's plan to place it in a diked area to be constructed at Hart and Milller Islands near the mouth of the Back River.[37] Under federal law the state of Maryland was responsible for providing a spoil disposal site, but the Corps was drawn into the Hart-Miller controversy because it had the responsibility of deciding whether or not to issue a permit to the state to create a disposal facility. The Corps judged the permit application under environmental guidelines it had developed in cooperation with the Fish and Wildlife Service and the Environmental Protection Agency. In conformity with NEPA, it was required to issue an Environmental Impact Statement on the permit since the project had significant potential impact on the environment. Between 1970 and 1981 the Corps issued three EIS's on the Hart-Miller diked disposal project.

In 1969, with passage of the 50-foot channel by Congress assured, the Maryland General Assembly appropriated $13 million for the selection of a dredged material disposal site. It was already known that much of the material from the harbor was contaminated with chemical dumping of the past hundred years and it could not be placed in the open waters of the Bay.[38]

The state commissioned Green Associates and Trident Engineering Associates to select a site and if necessary, design a diked containment facility to prevent the escape of the contaminated materials. The Green-Trident firms examined 70 disposal possibilities in 1970 and selected a site at Hart-Miller Island just north of the huge Sparrows Point steel complex for the construction of a diked containment facility. The site allowed the islands to be used to form part of the dike while sand deposits from dredging operations outside the contaminated part of the harbor were available to provide materials for the rest

The Hart-Miller site allows the island to be used to form part of the dike. Sand deposits from dredging operations were available to provide materials for the rest of it.

of it. There were no oyster beds or fish spawining areas close by, it was reasonably close to the harbor channel, yet it posed no obstacle to navigation. Within the diked area would be placed the 52 million cu. yd. of material from the channel dredging project. Water mixed with the dredged material would filter through the permeable dikes and would meet state and federal guidelines, but the contaminated sediments would be held in. These sediments would be covered with a layer of clean sand to keep the bottom layer moist and the pollutants, primarily heavy metals, chemically bonded to the sediment so they could not escape to the surface or penetrate the walls of the dike.[39]

In February 1972, the Maryland State Commission on Submerged Lands recommended the acquisition of the Hart-Miller site. The recommendation was approved by the state Board of Public Works, and Green Associates was asked to prepare working designs for the facility. The state filed an application with the Corps of Engineers to construct the disposal area.

The Baltimore District had already submitted a very brief EIS on the 50-foot channel in 1970, but it gave little attention to the disposal site since none had been selected by the state at this time and the Federal Water Pollution Control Act Amendments of 1972 were not yet passed.[40] The first detailed EIS on the project appeared in July 1972. It strongly endorsed the state's selection of the Hart-Miller site over all others discussed in the Green-Trident Report. Other diked containment sites were either too small to accept the amount of spoil required, or environmentally more questionable. Open water dumping was clearly unacceptable due to the amount and nature of the dredged material. Disposal in upland quarries or abandoned mines was too dangerous because these environments could allow the heavy metals to become separated from the silt and move into the local groundwater system.[41] The Hart-Miller dike structure was judged to be the best solution from both an engineering and environmental standpoint. "Evidence indicates," the EIS statement asserted, "that the water which will escape from the diked enclosure will not contain quantities of contaminants sufficient to cause pollution or in any way change the ecology of

Water mixed with the dredged material filters through the permeable dikes, but contaminated sediments are held in.

Fifty-two million cubic yards of material from the channel dredging project will be placed in the Hart-Miller diked containment area.

the upper Chesapeake Bay." Finally, the plan of the state of Maryland to develop the site as a recreational area, the statement said, "offers an opportunity to create one of the finest public parks on the Chesapeake Bay."[42]

The permit application hearing in August 1972 pitted the citizens living in the Back River area, plus a sprink-

Solid material from maintenance work on the approach channels is recovered with a minimum of water. It is then loaded on barges and taken to the Hart-Miller disposal site.

ling of environmentalists, against the Maryland Port Authority, the Baltimore business community and the state of Maryland. The leading spokesmen against the Hart-Miller location were Maryland Congressman Clarence D. Long, State Senator Norman R. Stone and State Delegate Donald Hutchinson—all three of whom represented the Back River area. Congressman Long said he visited the diked disposal area at Craney Island in the Norfolk area and heard residents complain about foul odors, beach erosion, water quality deterioration and the disappearance of fishlife "which are ruining the beauty of their property and lowering its resale value." Hutchinson, Long and Stone all criticized the state for failing to examine alternative sites more carefully. Alternative sites were, as State Senator Stone put it, "thrown in to justify why the Hart-Miller site should be used."[43]

In spite of lengthy reports and presentations of state officials, the Back River residents, and it appears, almost everyone in the Maryland legislature, believed the dredged materials from the harbor constituted an environmental liability for the community that would receive it. When State Senator Stone attempted to block disposal of the contaminated material at Hart-Miller, raising the possibility of its disposal at some other location in the state, every county delegation in the state (except Baltimore City) amended themselves out of consideration as a potential site.[44] Congressman Long pointed out that the Back River area, already the site of the region's sewage disposal plant, should not be expected to shoulder the burden of receiving the contaminated sediments of the harbor. The feelings of many local people were summarized by Senator Stone when he said, "...we already have in the [Back River] area most of the industry of Baltimore County, maybe the state. We already have in that area an outdated [sewage] disposal plant...and people are just a little tired of everything being put in that area."[45]

Due to the increasing number of engineering and environmental questions raised by opponents, and the necessity of holding an additional hearing in response to the enactment of Section 404 of the 1972 amendments to the Water Pollution Control Act, it took the Corps almost three more years to draft the *Final Environmental Impact Statement* and decide whether or not to issue the permit for the disposal site. The final EIS appeared in February 1976. This 300-page document presented a detailed analysis of the Hart-Miller dike system and discussed all its engineering, hydraulic, chemical and ecological impacts. In much briefer terms, alternative methods of disposal were discussed, including several not mentioned in the Green-Trident Report. None of these alternatives appeared to the Corps to be satisfactory. Disposal inland in quarries, gravel pits or strip-mined areas was re-examined and still found to be economically impractical and environmentally unsound. A suggested plan of turning the dredged material into bricks was examined but found to be too expensive. The nine alternative sites suggested to the Corps were studied, and none was found to be as environmentally suitable as Hart-Miller.[46]

Congressman Long, State Senator Stone, the Department of the Interior and the Environmental Protection Agency offered extensive and often critical comments on the EIS. They raised, once again, many questions regarding the impact of the Hart-Miller disposal site on the local environment and pointed to passages where they believed the impacts were understated or absent. The Department of the Interior noted the "great emphasis" placed by the state of Maryland on future development of the site as a public park, but wondered why the state had initiated no definite program to achieve this goal. Interior asked the Corps why it did not make public park development a condition of granting the permit. The Corps replied it was, "premature to stipulate permit conditions until the future of the proposed use of the islands, whether developed privately or purchased by the state, are determined.[47]

Both the Department of the Interior and the Environmental Protection Agency asked where the total accumulation of spoil for the 50-foot channel was to be deposited over the next 50 years, since that was the basis upon which the benefit-cost analysis was calculated. Hart-Miller's disposal area, as it was to built under the state's permit application, would be totally filled from the initial dredging and approximately 10 years of maintenance dredging. During the next 40 years another 48 million cu. yd. of maintenance dredging would be required, and there was "no mention...of any plans, suggested or proposed, to increase the size of the spoil area to accommodate 100 million cu. yd. of fill."[46] The Corps pointed to Vol. 3 of the Green-Trident Report, which discussed, in general terms, a variety of possibilities for expansion of the Hart-Miller site, but since the application was for only 52 million cu. yd., the Corps could not take this into consideration.[47] Even if the Corps had thought it appropriate to conduct such a study, there were no federal funds for it, and the state of Maryland showed no inclination to pay for it either.

On 22 November 1976 the, Baltimore District Engineer issued a permit to the state of Maryland to construct the diked disposal area at Hart-Miller Island. Congressman Long and opponents in eastern Baltimore County expressed dismay and proposed to take it to

the courts.[48] In June 1977, a local citizens group based in the Back River area, organized as the Hart and Miller Islands Area Environmental Group, Inc., along with Congressman Long, State Senator Stone and several other individuals, filed suit in Maryland District Court to overturn the permit decision. In addition to a challenge to the Corps' authority to approve the facility without a specific congressional authorization, the plaintiffs asserted that the Corps had not examined carefully enough the structural safety of the dike or alternative disposal sites, and had not addressed the issue of future disposal sites or the cumulative effects of these facilities on Chesapeake Bay.

The legal challenge to the Corps' authority to approve the Hart-Miller site without the specific approval of Congress was won by the plaintiffs in Federal District, in 1978, overturned by the United States Court of Appeals for the Fourth Circuit in May 1980, and was refused review by the Supreme Court in November 1980. In December 1980, the Maryland District Court, ruling on the environmental issues, found the Corps had complied with the requirements of all pertinent federal laws and regulations regarding the permit and refused to rule on the intrinsic quality judgments and research of the Corps in reaching its decision. In April 1981, foes of the project decided not to appeal the district court decision upholding the Corps' EIS, saying they had already spent over $20,000 on the legal battle and felt they could not raise the $5,000 it would take to make the appeal.[49]

Construction of the diked disposal facility at Hart-Miller Island began in 1981 and was completed in December 1983. Dredged materials from maintenance work on the approach channels in addition to contaminated materials from the harbor itself have been deposited at the facility during 1984-1987. This has been closely monitored by the Corps and the state of Maryland. The work was done with a clam-shell dredge that recovers solid material with a minimum of water. It is then loaded onto barges and taken to the Hart-Miller disposal site. No problems developed during this small-scale rehearsal for the 50-foot dredging project, which finally began in 1987.

The environmental monitoring of the 50-foot channel program is itself a vast enterprise that has occupied the Navigation and Environmental branches of Operations and Planning divisions at the Baltimore District for a number of years. The Maryland monitoring program is jointly funded by the state and the Corps, with the Corps contributing $380,000.[50]

The monitoring program for the Virginia channels is being conducted by the Baltimore District in cooperation with the Norfolk District and the Commonwealth of Virginia. It is the largest and most elaborate environmental monitoring program undertaken by the Baltimore District. A baseline pre-dredging program costing $1.4 million was carried out in the mid-1980s. It consisted of detailed bathymetric surveys of the disposal sites, which will allow post-disposal analysis of the changes to the area from the disposal program. A survey of benthic conditions at each disposal site before, during and after disposal will provide an excellent case study of the effects of dredged material disposal on the local benthic communities, and possibly provide indications of how future disposal programs can minimize adverse effects or improve its resource value. Finally, the overboard disposal of dredged material will be monitored to document the degree to which sediment dispersion might be expected. The environmental monitoring program will continue throughout the actual dredging period of approximately three years and continue afterwards to assess the long-term effects. The cost of this phase will be approximately $1.6 million.[51]

The Baltimore District had plenty of time to develop its monitoring program due to a six-year additional delay in the project after 1981, which stemmed from the protracted debate at the national level over the method of financing the nation's water resource development projects. The Reagan administration, which entered office in 1981, believed local sponsors of water resource projects should pay a portion of the costs. After a long series of negotiations and congressional debates, the Reagan administration agreed to fund the 50-foot channel, provided that the state of Maryland pay approximately 40% of the costs. In order to reduce the cost, Maryland and the Corps agreed to constrict the channel widths to be deepened and this brought the cost down from $326 million to $242 million, and reduced the volume of dredged material from 66 million cu. yd. to 52 million (25 million in Virginia and 27 million in Maryland).[52] On 18 June 1986, a cost-sharing agreement was signed by Governor Harry Hughes of Maryland and Assistant Secretary of the Army for Civil Works Robert K. Dawson. The agreement paved the way for inclusion of the project in the 1986 Water Resource Development Act, approved by the President on 17 November 1986. Dredging commenced on 2 June 1987, almost 20 years after Baltimore's leaders and the Corps began work on the project.[53]

Chapter V
Small Channel Dredging and Demonstration Projects

While the Baltimore Harbor and the C & D Canal channels capture most of the headlines in the newspapers, the Baltimore District has approximately 120 other federally-authorized dredging projects which periodically require maintenance work. Most of the smaller channels in the Bay are 7 feet deep and 60 feet wide, but a few are larger. The Nanticoke and the Tred Avon channels are 12 feet deep and the Wicomico channel is 14 feet. The Bay's smaller channels can present complex environmental and economic problems, but they have also yielded some of the most innovative and promising dredged material disposal solutions.

The dredging itself no longer causes any serious environmental problems. There are very few new federally-authorized channels in the Bay and they are quite small, so almost all dredging is connected with the maintenance of existing channels. Each instance of dredging, even for quite small projects, is coordinated by the Baltimore District with all the federal, state and local agencies having an interest in the marine life, environment and navigation of the areas scheduled for maintenance. These agencies are the National Marine Fisheries Service, the Fish and Wildlife Services, the Environmental Protection Agency, the Maryland Department of Natural Resources, and, in the case of small projects, county public works departments. Representatives from these groups meet with Baltimore District officials every six months, to agree on the best timing and methods of dredging and, of course, to discuss the problem of disposal. For a number of years the schedule of dredging in the Bay has been timed to avoid harming marine life during periods when it is vulnerable. There is no dredging near oyster bars between June and September, no dredging in blue crab areas between May and November, and none in anadromous fish-spawning areas between February and July. This leaves a relatively short period for dredging and drives up the cost of the work, but it is one of the unavoidable prices paid for a better marine environment.

Cutterhead dredges loosen bottom material and then suck it up through large pipes. The Hopper Dredge **Essayons** *is shown here. (Photo courtesy North Atlantic Division)*

To make sure its dredging periods are not overly restrictive, the Baltimore District continues to collect information and encourages further research on the interaction between dredging and marine species. One recent example of this is focused on dredging in the vicinity of oyster beds. Experts have not agreed on the degree to which the productivity of oyster beds is reduced by the destruction of a certain amount of oyster larvae due to their entrainment by hydraulic cutterhead dredges, the type most commonly employed in the Bay. These dredges loosen the bottom material and then suck it up through large pipes, which pump it to a disposal site. In performing this task, the dredges suck up millions of gallons of water in which oyster larvae swim. Larvae taken up into the section pipe are destroyed. The question raised by some is whether this leaves enough larvae to populate the local oyster beds. The Baltimore District sponsored a workshop on this subject in 1985 at the University of Delaware College of Marine Studies. A number of the district's experts met there with scientists and experts from around the nation to discuss the issue. They agreed the question was difficult to resolve without more research and echoed the Corps' belief that each case is slightly different and no universal rule can be applied. Several scientists presented evidence they believed showed larvae entrainment was not a serious problem, but since there was no consensus, the Baltimore District has continued to avoid the entire June-September period when dredging in oyster areas.[1]

Compared to the dredging itself, the disposal of dredged material, even in relatively small projects, presents a serious problem to local sponsors. In almost all navigation projects except the Baltimore channels, the local sponsor is the county government. According to federal law they must provide, at their own expense, an acceptable disposal site. This was never difficult before the coming of the environmental legislation. Local sponsors just pumped the dredged material onto a marsh or adjacent wetland. The Corps of Engineers had no authority to reject this solution on environmental grounds until the NEPA and the Clean Water Act were enacted; the Corps could only object if the disposal solution interfered with navigation. Today, however, Baltimore District and the state of Maryland operate under new, very strict environmental guidelines.

The Wicomico River navigation channel leading from the Bay to Salisbury, Maryland, on the Eastern Shore provides a good example of how local governments, in cooperation with the Corps, have altered their dredged material disposal practices since NEPA and the 1972 Clean Water Act amendments. With the

help of the Baltimore District and other agencies, Wicomico County has found environmentally-sound solutions to its dredging problem, but the cost is now higher. The county and the city of Salisbury depend on the Wicomico River channel for the delivery of petroleum and other bulk items. The channel is 14 feet deep, 150 feet wide and approximately 37 miles long, the distance from deep water in the Bay up the river to Salisbury. The gradual deepening of the Wicomico channel plus maintenance dredging during the 20th century has deposited over 10 million cu. yd. of material in adjacent wetlands.[2] Owners of wetlands were usually eager to have them filled since it added considerably to their commercial value. With the passage of NEPA in 1969 and the Clean Water Acts of 1972 and 1977, this disposal practice had to cease. Wicomico County officials had to find upland sites and were ultimately forced to purchase them. Land costs keep increasing as does the construction of the diked containment areas because they must meet state and federal standards. The 25-acre Adkins diked disposal site near Salisbury was the largest owned by the county as of 1987. Before it could be used, the site had go through an environmental assessment process which involved study by the Corps of Engineers, Fish and Wildlife, National Marine Fisheries, EPA, and the Maryland Department of Natural Resources. In addition, the Maryland Historic Trust assessed whether the site possessed significant archeological value. Finally, the Maryland Health Department had to issue a Water Quality Certificate assuring that the structure met Maryland guidelines for the water quality of the effluent seeping through it as the dike was filled.[3]

Though marsh creation is not especially complex, the site is selected with great care, and careful research, planning and execution is required. This 6-acre marsh was built from dredged materials at Slaughter Creek by the Baltimore District.

To ease the burden on local sponsors, the Corps monitored effluent water quality at contained upland disposal areas such as the Adkins site. This program helps reduce costs by meeting environmental guidelines more quickly and efficiently. At Adkins, the filling of confined upland disposal sites was accomplished by pumping the dredged material from the navigation channel to the disposal site through large pipes. The solid material was mixed with water. This mixture, about 80% water and 20% solids, settled out in the disposal area, the solids gradually sinking to the bottom and the more clear water returning to the river through sluices at the top of the dike that led to a stream. The state of Maryland requires that the turbidity level of this effluent not exceed 400 milligrams of suspended solids per liter, and the Corps monitored the effluent to assure compliance with this rule. Because of concern over water quality in the Bay, the Maryland requirement is more strict than most other states. Verification requires taking samples from the effluent to a laboratory for testing, a process that can take 24-48 hours. During this time no filling can proceed and the expensive dredging and pumping equipment and its crew must sit idle, all at county expense. To speed up the analysis, H. Glenn Earhart, a biologist with the Operations Division of the Baltimore District, experimented in 1981 with a new type of portable nephelometer that measured the amount of light passing through a water sample, giving an

instant turbidity reading at the disposal site. Working with several other Corps experts, he developed a correlation curve, relating the nephelometric readings to the total amount of suspended solids. This procedure worked very well at the Adkins site and has the potential of becoming a much more cost-effective method of measuring turbidity to comply with the state's 400-milligram regulation. Local governments can save thousands of dollars in dredging costs, and the effluent can be monitored more frequently. Money is saved and environmental quality is improved. This is one of the real benefits of maintaining a permanent staff of scientific experts in Corps district offices who can combine scientific theory and the latest technology with their practical experience in the field.[4]

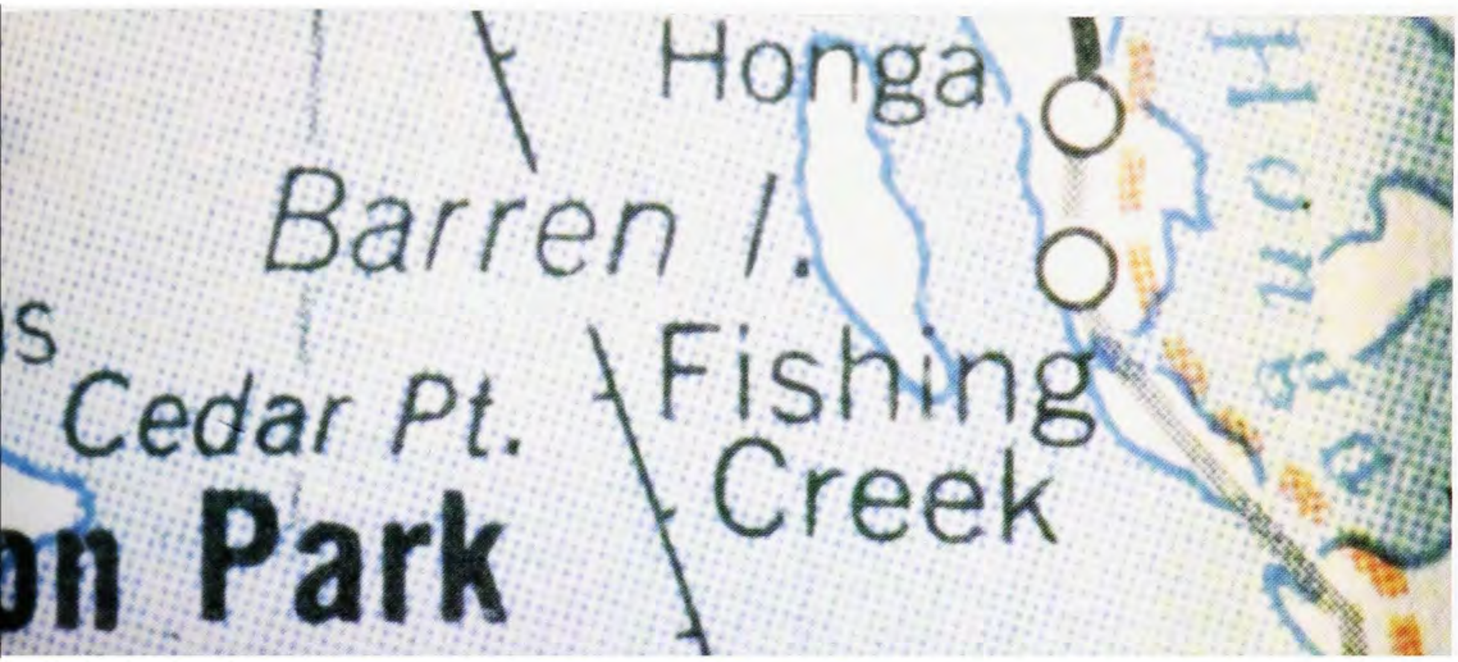
The high cost and the environmental problems associated with upland contained disposal sites is one of the reasons that local governments try, if at all possible, to gain approval to dispose of their dredged materials in open water. This is what led Congress to direct the Corps of institute a dredged material research program in the 1970s. At the same time, various Corps districts, including the Baltimore District, began a series of small experimental disposal projects using materials from regular channel maintenance activities.

The first such experiment for the Baltimore District was in 1972, when it successfully created a four-acre marsh at Charity Point in Dorchester County, using dredged materials from the Honga River. In 1974, it built a six-acre marsh not far away at Slaughter Creek.[5] The creation of a marsh is not especially complex, but it requires careful research, planning and execution. The site has to be selected with great care. The annual cycles of tides, currents and wave action must be accurately plotted so the dredged material placed on the site will not drift to some other location. The depth and gradient of the marsh floor must be exactly correct for the selected aquatic plants to grow. A difference of a few inches in the gradient will make a large difference in plant growth. The plants or seeds must be chosen to fit the local environment and the dredged material must be carefully analyzed to be sure that it has a physical and chemical composition compatible with the materials upon which it will be deposited. The whole operation must be timed to meet both the local dredging window and the marsh plant growing season.[5]

A second type of beneficial-use project has been beach nourishment. In these projects, dredged sand from navigation channels is deposited on beaches to

Dredged material from the Honga River channel created a 55-acre complex of wildlife habitats adjacent to Barren Island. Least terns have a less vulnerable nesting area here.

slow down, at least temporarily, their erosion. Once a beach has eroded, waves break directly onto the fastland and owners begin to lose their property. This operation requires much the same type of planning and execution required for marsh building. It has been used extensively at Knapps Narrows, on the Chester River at Rich Neck (with material dredged from the Claiborne Harbor Project) and at Rhodes Point on Smith Island. The major problem with beach nourishment is the dynamic nature of many beach areas. A local government or group of shoreline residents may urge the Baltimore District to pump sand onto their disappearing beach. But if the wave action and currents are judged to be such that they will soon

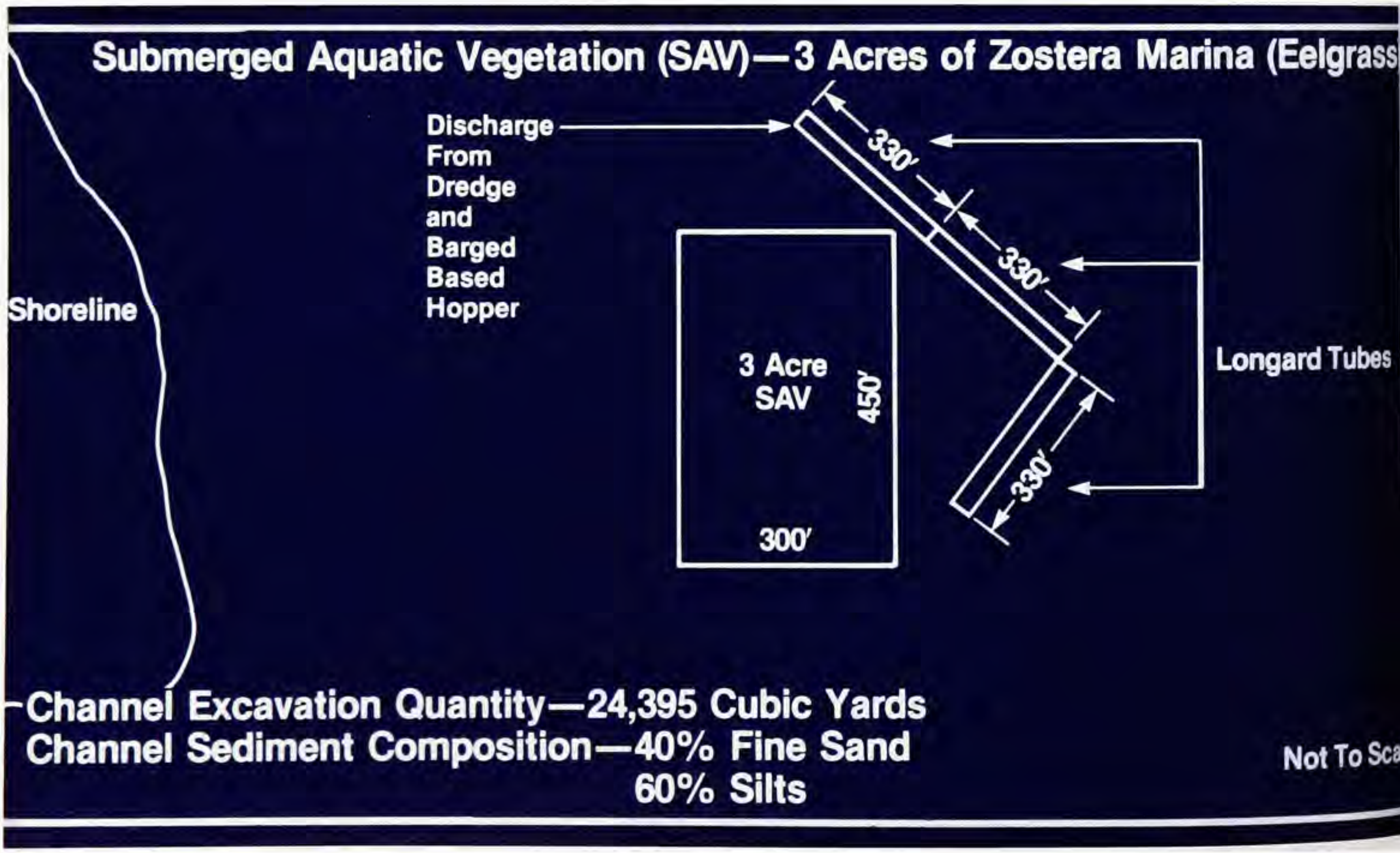


move that sand off the beach, possibly onto a bottom area where it will cause problems, the district is quite reluctant to undertake such an action. Also, if the dredged material is incompatible with the materials on which it would be placed, the district is usually unwilling to do this, because studies show such a practice makes it much more difficult for the area to recolonize its indigenous aquatic species. Beach nourishment is now reasonably well understood and is being applied by the district in an increasing number of areas where it is environmentally sound and economically feasible.

The largest and most elaborate beneficial use project the district has undertaken so far is at Barren Island in Tar Bay near the entrance to the Honga River. Under the direction of Glenn Earhart, the district used approximately 332,000 cu. yd. of dredged material from the Honga River channel to create a 55-acre complex of wildlife habitats adjacent to Barren Island. The Honga River channel is heavily used and shoals fairly rapidly, so it requires regular maintenance dredging. The dredged material was the same type of sandy silt used to create the Charity Point marsh in 1972. In 1981, the Baltimore District decided to create a much larger and more complex series of habitats in shallow water at the north end of Barren Island. The dredged material was pumped to the site and deposited in a series of mounds approximately 4 feet above mean high water in a pattern that allowed the area to be flushed by the tides as would occur in a natural marsh. The perimeter of the area and certain other sections were planted with two types of marsh grasses.[6]

Half an acre was covered with sand and shells in the hope it would become a nesting area of least terns, a migratory bird that once summered in great numbers on the beaches of the Chesapeake Bay. Their plumage became a fashionable millinery item in the late 19th century, and the birds were almost exterminated by plumage hunters. Presently only a few small colonies are left. The terns nest on open, isolated beaches, laying their eggs in shell-and-sand areas just above high water. They are now protected from

The technologically challenging Twitch Cove project is on the east side of Smith Island, the site of one of the Bay's most famous and ancient fishing communities.



hunters, but their nests are quite vulnerable to humans in more populated areas, and to natural predators elsewhere.[7] The Corps' artificial island seemed to offer good protection from both those dangers. The initial distribution of habitats on the 43-acre area were 10 acres of shallow ponds, 22 acres of *spartina alterniflora*, (cord grass), 6 acres of the more slender *spartina patens* (salt marsh grass), 4.7 acres of unvegetated bird nesting area, and 0.5 acres of sand and shells for the least tern nesting area.[8]

The Corps completed dredging during the fall of 1981. The following spring, Environmental Concern, Inc., of St. Michael's, Maryland, a firm specializing in the creation of aquatic habitats, planted the island. The cord grass and marsh grass thrived and by summer the lush greenery stabilized the fine-grained dredged material. *Ruppia maritima* (widgeongrass), grew in the shallow waters around the artificial island before the dredged material was dumped on top of it, but it quickly recolonized. The new beds were considerably larger than the ones that had been buried.

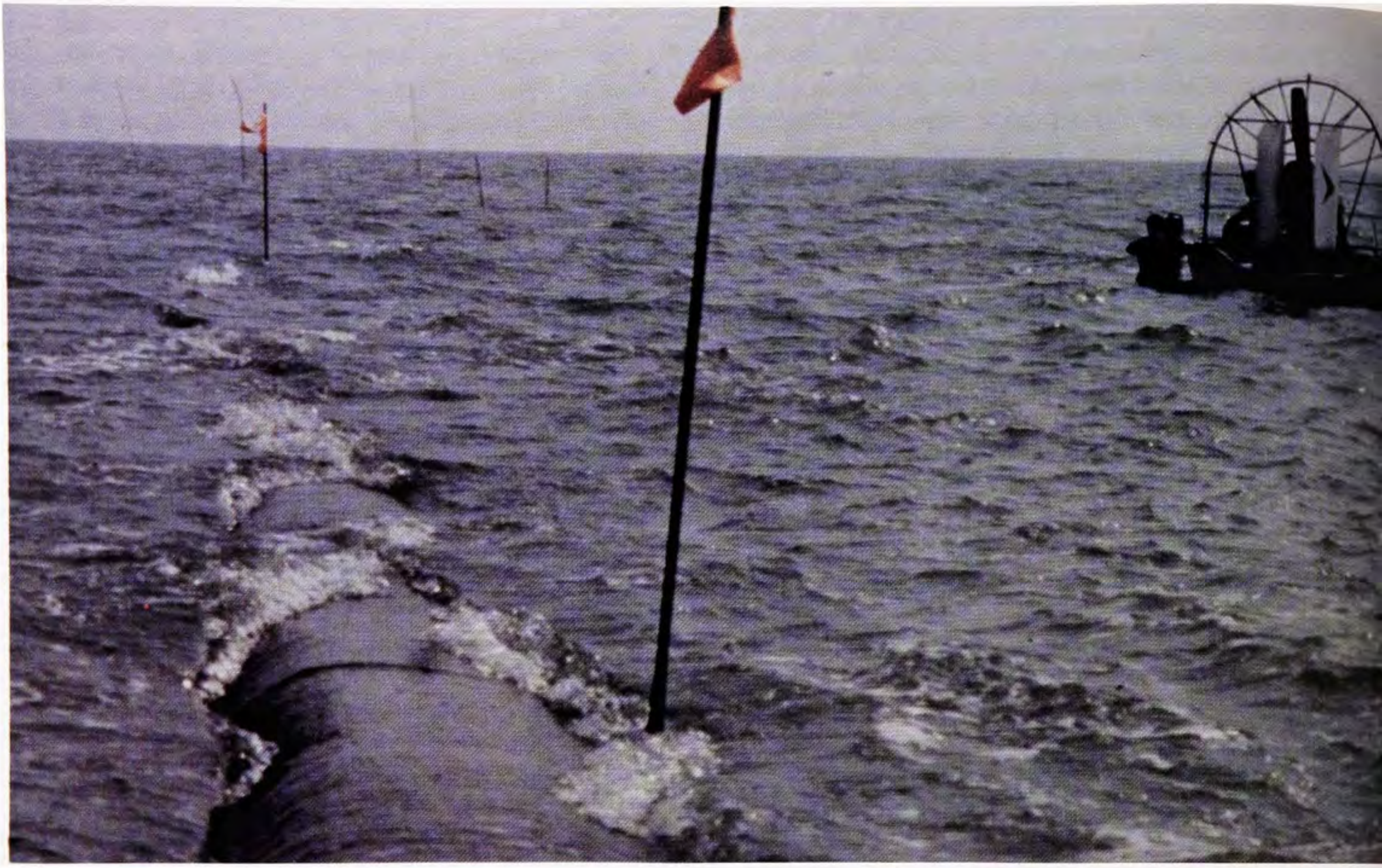
The greatest success, however, came in the least tern habitat. In June 1982, the Corps found approximately 50 least tern nests, each with several eggs in it. The next month, after the eggs hatched, Corps officials counted a minimum of 460 birds. They also found other species of water birds were inhabiting the new island. In the winter of 1982, the Corps placed more sand and shells on the island to attract more least terns. During channel dredging in 1985, the Corps created another 11.9 acres of habitat extending out from the original island and developed it for several types of habitat. In April 1985, the entire area was turned over to the Maryland Department of Natural Resources (MDNR) which established it as the Barren Island Wildlife Management Area. MDNR is responsible for its maintenance.[9] Unfortunately, the area is so conducive to the growth of vegetation that even the sand and shell habitat has sprouted ground cover. This requires annual cutting, since least terns are quite fussy about such matters and will not use the site unless it is clear. Creating and maintaining natural habitats of this sort is akin to keeping a large garden. It requires careful planning and regular maintenance in order to attract and hold more fragile species.

On the economic side, the Barren Island habitat was far less expensive than a more traditional upland disposal site. The Corps estimated it would cost about $250,000 to place the same amount of dredged material used at Barren Island at an upland site. The Barren Island project cost $106,000. The key to the lower cost was planting the grasses from seeds rather than transplanting shoots. Transplanting is a laborious task costing roughly seven times more than seeding, but it is more successful. [10] The success of the Barren Island project, from an environmental as well as economic perspective, was due to a great deal of detailed planning plus two very knowledgeable and skilled private contractors—a dredging company which created exactly the correct slope and contour and an aquatic habitat firm that knew exactly how to develop the grass cover.

Less exotic, but more technologically challenging is the Twitch Cove experimental project on the east side of Smith Island, the site of one of the Bay's most famous and ancient fishing communities. The Twitch Cove shoreline is seriously eroding. In the summer of 1987, 24,000 cu. yd. of dredged material removed from the navigation channel of the Big Thorofare River was placed in a 3-acre site in Twitch Cove. It was planted in September with eel grass, a submerged aquatic grass, that when fully grown should dissipate enough wave energy to slow down erosion of this area of the cove.

The wave action is too strong to allow the submerged vegetation shoots to take root, so the district built a temporary breakwater in front of the area with six "longard tubes" placed in the right configuration to break the wave action until the submerged vegetation is strong enough to stand on its own. The longard tube is a thick, impermeable polyethylene tube 48 inches in diameter and 330 feet long. Six of them were taken out into the water, unrolled, and filled with dredged material to form the 1,980-foot long breakwater. Once the aquatic grasses have firmly established themselves, the tubes can be removed. The technology is quite new in the United States but has been used for some time in Europe. As manufacturers of these types of products continue to increase product longevity, tubes can be moved inexpensively from site to site to provide temporary shelter for new beds of aquatic vegetation. Even with the current generation of tubes, which have a life of three years, this project cost about $30,000 less then upland disposal.[11]

The other most recent effort in the current series of experimental demonstration projects uses dredged materials to recreate an oyster bar. In cooperation with the National Marine Fisheries Service and the Maryland Department of Natural Resources, the district used dredged material from the Slaughter Creek Channel in Dorchester County to rehabilitate an existing but unproductive oyster bar which had silted over and developed too soft a bottom. In this experiment approximately 10,000 cu. yd. of sandy material from the 1987 maintenance dredging of the Slaughter Creek channel was pumped about 7,000 feet out into

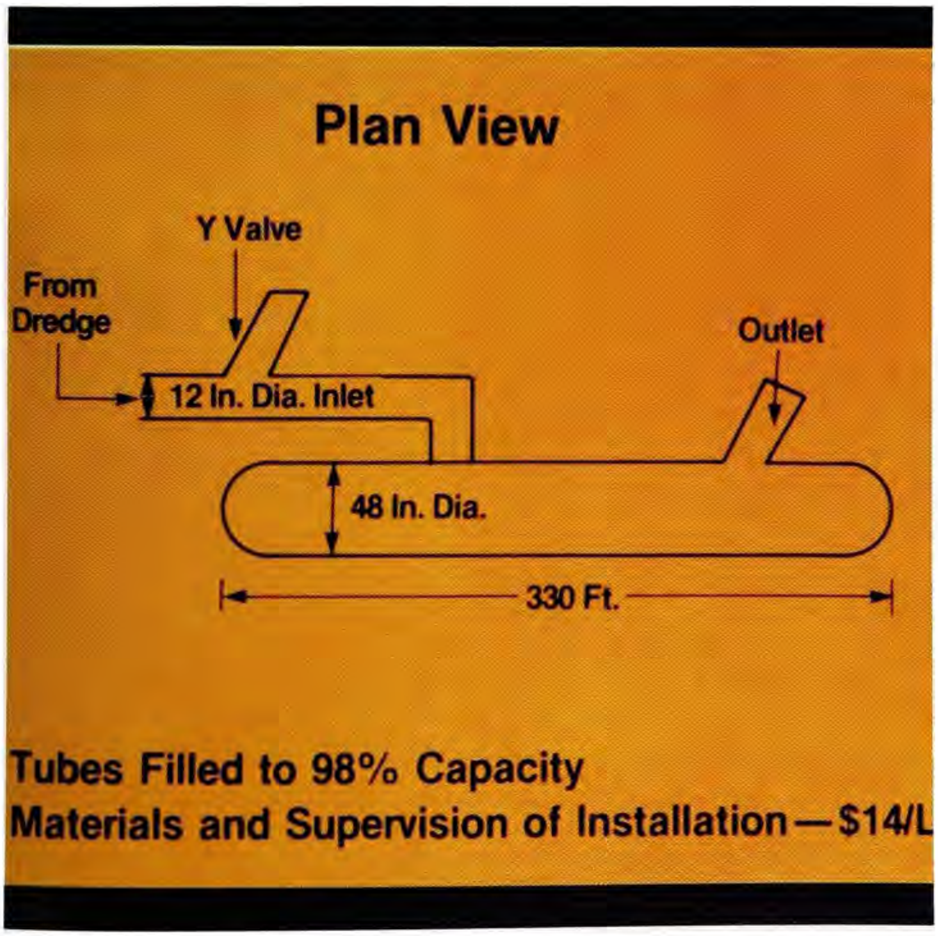


the Little Choptank River to the site of the old oyster bar. It was deposited in a 3-foot thick mound over the existing bottom and covered 2.1 acres. An eight-inch cap of old oyster shells was placed on the mound to establish a new bed for oyster spat. In the spring of 1988, researchers found the oyster bed had become productive with a spat count comparable to that found in other newly seeded oyster beds. Once again, the cost of this experiment was approximately $85,000 less than the cost of placing the material in a standard upland diked disposal facility.[12]

All these projects were discussed at a regional workshop on the beneficial uses of dredged material the district held in Baltimore in May 1987.[13] It was apparent to the participants that beneficial uses concept is now well established and new types of projects are going to come along rapidly. There were also cautions raised that this is a new and largely unexplored area where the application of general concepts will be different at every specific site. Ideas and techniques that work in one location may not transfer to other places.

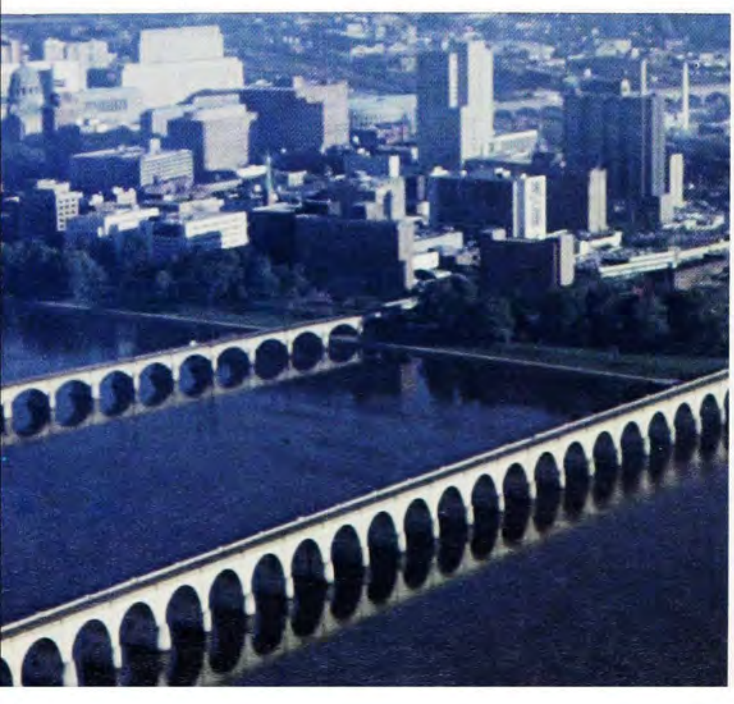
Policy questions are equally significant in this area. The use of dredged materials to create a new habitat means an older and different one is being replaced with something that will have an impact on aquatic and/or terrestrial creatures not only in the area where the dredged material is placed, but in a region that will extend beyond the limits of the project itself. For example, changing a shallow water environment into a marsh will alter the numbers and types of fish, insects, birds and mammals in the area. Will this alteration benefit the larger area and its population mix? Some fears were expressed at the Corps workshop that even the most carefully conceived plans to alter an environment may have unforeseen negative impacts.

Such cautionary lectures as these are important since they are reminders of the fragility and complexity of the web of life in the Chesapeake Bay. Sadly, in an area like the Chesapeake, the hand of man has already so fundamentally altered its ecology —certainly in areas where navigation channels exist— that Corps ecologists and engineers are almost never intervening in an area totally unaltered or degraded by man. Also, there is a clear political consensus that Bay navigation channels must be maintained. Consequently, millions of cubic yards of dredged material must be disposed of in some way. It falls to the Baltimore District to do this in a way that does



A temporary longard tube breakwater protects eel-grass, newly-planted on dredged material removed from the navigation channel of the Big Thorofare River, from strong wave action at seriously eroding Twitch Cove, while the shoots take root. The grass should dissipate enough wave energy to slow erosion at this area of the cove.

no permanent environmental damage and, if possible, contributes to Bay restoration. The key to this balancing act is to build and hold together a staff of engineers, scientists and technicians who have both a firm grasp of the current state of scientific and technical knowledge and substantial field experience in the geographic area where dredging and disposal projects are to be carried out. There must continue to be experiments with new projects like Barren Island, Twitch Cove and Slaughter Creek. Careful monitoring of project sites before, during and long after they are constructed is also of great importance. The full ramifications of their impacts, both positive and negative, need to be recorded and made available to inform future dredging and disposal activities. In this way the Corps, and the other agencies involved in keeping the waterways of the Bay open, will be able to accomplish this necessary economic activity in the most environmentally sound way.



Chapter VI
The Potomac, Susquehanna and the Bay

The rivers flowing into the Chesapeake Bay are both friend and foe of the estuary's ecological balance. The Chesapeake depends on them for fresh water, minerals, and nutrients, but the Bay can also be victimized by them. Rivers often carry pollutants or too many nutrients. When droughts hit, the Bay's rivers fail to deliver enough fresh water. The Bay becomes much saltier and commercially important species like the oyster suffer. When floods come, the rivers carry tremendous amounts of fresh water and sediments into the Bay with equally devastating impact on aquatic life.

The Susquehanna and the Potomac stand apart from all the Bay rivers as the two largest and most influential. Within the 64,160 square mile drainage area of the Chesapeake, the Susquehanna accounts for 43% and the Potomac for 22% of this land area. The total average inflow of fresh water to the Bay is 76,890 cfs. The Susquehanna makes up 51% of this amount and the Potomac 18%. Together, these two

The Susquehanna and the Potomac drain 54% of the Chesapeake watershed and supply 69% of its fresh water. These rivers supply almost 90% of the fresh water in the Maryland portion of the Bay, while the Rappahannock, James and York rivers together supply 21% of the fresh water, most of which remains in the lower Bay.

rivers drain 54% of the total Chesapeake watershed and supply 69% of its fresh water. In the Maryland portion of the Bay they supply almost 90% of the fresh water (the Rappahannock, James and York together supply 21% of the total fresh water, most of which remains in the lower Bay.)[1]

There is a tug of war going on over the freshwater supplies coming down the Bay's rivers. The growing population centers, industrial plants, power companies, and agricultural interests all use this water and much of it is never returned. There is no problem when rainfall is plentiful; but when droughts come, as they do quite regularly in this watershed, the increasing withdrawals from an already low-flowing river can create serious and expensive problems for all water users. For this reason, the Baltimore District has devoted a great deal of time and energy examining the problems of water supply and flood control along its two major rivers. More recently it has been authorized to make a preliminary study of the water supply question for all the Chesapeake's major rivers since their ultimate freshwater "user" is the Bay itself and the Baltimore District is the lead district in Baywide studies.[2]

The Corps and the Potomac

The Potomac is one of the most beautiful rivers of the eastern United States and its estuary is the largest of all the Chesapeake tributaries. Unfortunately it is also a river with unusally large fluctuations in its flow. Average flows in the Potomac run from 20,000 cfs in the spring to 5,000 cfs in the fall. Flows of 1,500 cfs occur 10% of the time. The river can show remarkably rapid changes. In November 1985, one of the worst floods of the 20th century did over $300 million in damage to the upper Potomac basin and pushed peak flow to 292,000 cfs. This was followed by one of the worst droughts, and by September 1986, the flow had dropped to 1,300 cfs or approximately 900 million gallons a day (mgd). Washington's water supply intakes removed about 400 mgd in September, so the amount left to flow into the Potomac estuary and the Bay was even smaller.[3]

The Corps of Engineers plays a unique role on the Potomac because the river is the site of the District of Columbia. In 1851, Congress authorized the Corps to supply the District with "an unfailing and abundant supply of good and wholesome water." Corps engineers built the Washington Aqueduct, tapping the supply of the Potomac River at Great Falls, Maryland, several miles above the capital.[4] Congress still relies on the Corps to maintain this vital utility and has made it clear the Corps has authority to withdraw as much water from the river as is necessary for the District of Columbia. Washington area suburban water agencies are free to make withdrawals from the water remaining in the Potomac, so long as 100 mgd are left to flow into the Potomac estuary and the Bay. If the natural flow of the Potomac alone was relied upon for all these uses, there would have been several summers in the past 25 years when many Washington area families would have been severely restricted in their water use, and the flow of fresh water into the Potomac estuary would have dropped to a trickle. Fortunately, during these years the Corps developed, in cooperation with a host of state and local agencies, its pioneering intergovernmental drought management program for the Washington area. It is a plan based on the decision to maintain a minimum flow into the Bay even during the most severe droughts.

There was no serious water supply problem on the Potomac until the 1950s. The river has a long history of low flows during droughts, but the relatively small size of Washington's population and even smaller size of its suburbs allowed the river to provide enough water for everyone. Problems would have arisen earlier in the century had not Maryland's suburbs created the Washington Suburban Sanitary Commission (WSSC). The WSSC built a water supply system based on the neighboring Patuxent River basin, which lies just north of the capital region.

In spite of the efforts of Washington area water agencies, local governments found it difficult to keep up with demand. The great expansion of federal employment from World War II onwards and even more rapid growth in the private sector, sent the Washington area population soaring. Withdrawals of water from the Potomac increased even more rapidly. Washington area local water supply agencies in Maryland and Virginia developed some additional small reservoirs, but were forced to rely increasingly on the Potomac. Aside from one small (5.9-billion gallon capacity) dam built by the Corps on the Savage River in western Maryland during the 1930s to supply water for several local industries on that river, there were no federally-constructed dams at all on the Potomac or its tributaries.[5]

A water supply crisis appeared inevitable and the flooding problems were still serious, so in 1956 Congress authorized the Corps to undertake a study of the Potomac basin water resource problems.[6] Three problems attracted the most attention: flood control, pollution abatement, and water supply. The obvious answer to these three problems appeared to be a series of large multi-purpose reservoirs that would supply water during droughts, but could also catch and store flood waters.

The Corps relied on the U.S. Public Health Service (PHS) to provide estimates of future water supply needs in the basin. The PHS estimated that by the mid-1980s, there would be severe water shortages in the Washington area during droughts, even if the entire flow of the river was diverted for water supply. The PHS was unsure how much minimum flow needed to be maintained past the Washington water supply intakes to keep the Potomac estuary and the Bay from becoming too severely degraded, because it did not yet know the degree to which improvements in sewage treatment systems along the river would reduce pollution levels. Even with the improvement of sewage treatment plants along the river and its tributaries, experts recognized that the Potomac estuary and the adjacent area of the Bay would become much more polluted and brackish if the Potomac ceased to flow into it during droughts. The state of Maryland, to whom the Potomac belongs, began to examine how much freshwater flow was required to maintain the biological balance of the Potomac estuary. This took a long time. In the late 1970s, the state finally put the figure at 100 mdg. This became the base figure from which the Corps developed its final water supply plans.[7]

Back in the 1950s, however, the PHS had thought the minimum flow-by would need to be at least several hundred mgd. There would certainly have been no problem providing this amount of freshwater, and a great deal more, if the Corps had been allowed to build all the Potomac basin dams it recommended. The Corps' 1963 *Potomac Basin Report* estimated that the needs of the river for water supply, flood control and "pollution dilution," would require 16 reservoirs on the Potomac tributaries and a gigantic dam on the main stem above Great Falls that would have submerged much of the historic C & O Canal and backed the river up to Harpers Ferry. For years under a variety of pretexts, the Corps had been trying to build a large dam near Great Falls, and this was just another attempt with a slightly new series of justifications. The 16 dam program represents the nadir of Corps planning in the Chesapeake region. It looked as if the engineers wanted to drown the entire Potomac basin, and the justification they presented for this destructive program was proven by a later generation of Baltimore District officials to have been seriously flawed. This incredible recommendation was greeted with dismay by local residents in the areas to be inundated and by environmentalists, naturalists, and political leaders all across the nation.[8]

Because of the huge public outcry against these proposed reservoirs, Congress did not move forward on their approval, and in 1965, President Lyndon Johnson created a Presidential Task Force, headed by Secretary of the Interior Stewart Udall, to halt the Corps of Engineers from building any dams on the Potomac River. During the late 1960s, the District put forward a plan for six dams on tributaries of the Potomac, but by this time opposition was very well organized and politically influential. The Corps was forced to reduce the number of large dams from six to three. Verona dam on the South Fork of the Shenandoah River near Staunton, Virginia, Sixes Bridge dam on the Monocacy River near Frederick, Maryland, and Bloomington dam on the North Branch of the Potomac in the remote western corner of Maryland. Strong local opposition to the Verona and Sixes Bridge proposals caused further delays.[9]

In 1974, Congress responded to the suggestion, coming largely from local opponents to the Verona and Sixes Bridge projects and Potomac area environmentalists, that the Corps restudy the whole Washington area water supply question. The Water Resources Development Act of 1974, authorizing the restudy, required the Corps to examine tapping the freshwater portion of the Potomac estuary during droughts, since improvements in wastewater treatment appeared to make this a feasible, if not very palatable alternative. The Baltimore District was authorized to design and construct a pilot water treatment plant in the Potomac estuary, and this was completed in 1981.[10] The possibility of using the estuary plus a strong local opposition to the Verona and Sixes Bridge dams caused their respective state governments to withdraw support, and the two projects died. However, Bloomington dam (recently renamed Jennings Randolph dam), in an almost uninhabited area of Maryland, had little opposition, and its 31 billion gallon storage capacity was far larger than either Verona or Sixes Bridge would have been. This huge dam was completed in 1981.[11]

The reduction of the Corps dam building program from sixteen to only one appeared to be real disaster for the Washington water supply agencies, but it turned out not to be so. During the 1970s, a new generation of analysts and planners came into positions of responsibility in the Baltimore District, who had access to better information, new analytical tools and possessed a more enlightened attitude towards the whole question of damming rivers. New population figures for the Potomac basin indicated a lower growth rate than had been projected in the early 1960s. The most important tools to become available to the new planners were the new generation of computers and software programs that allowed an entirely fresh insight into the Potomac water supply problem.

By 1977, the Baltimore District had developed the

The dam (above) at Jennings Randolph Lake was completed in 1981.

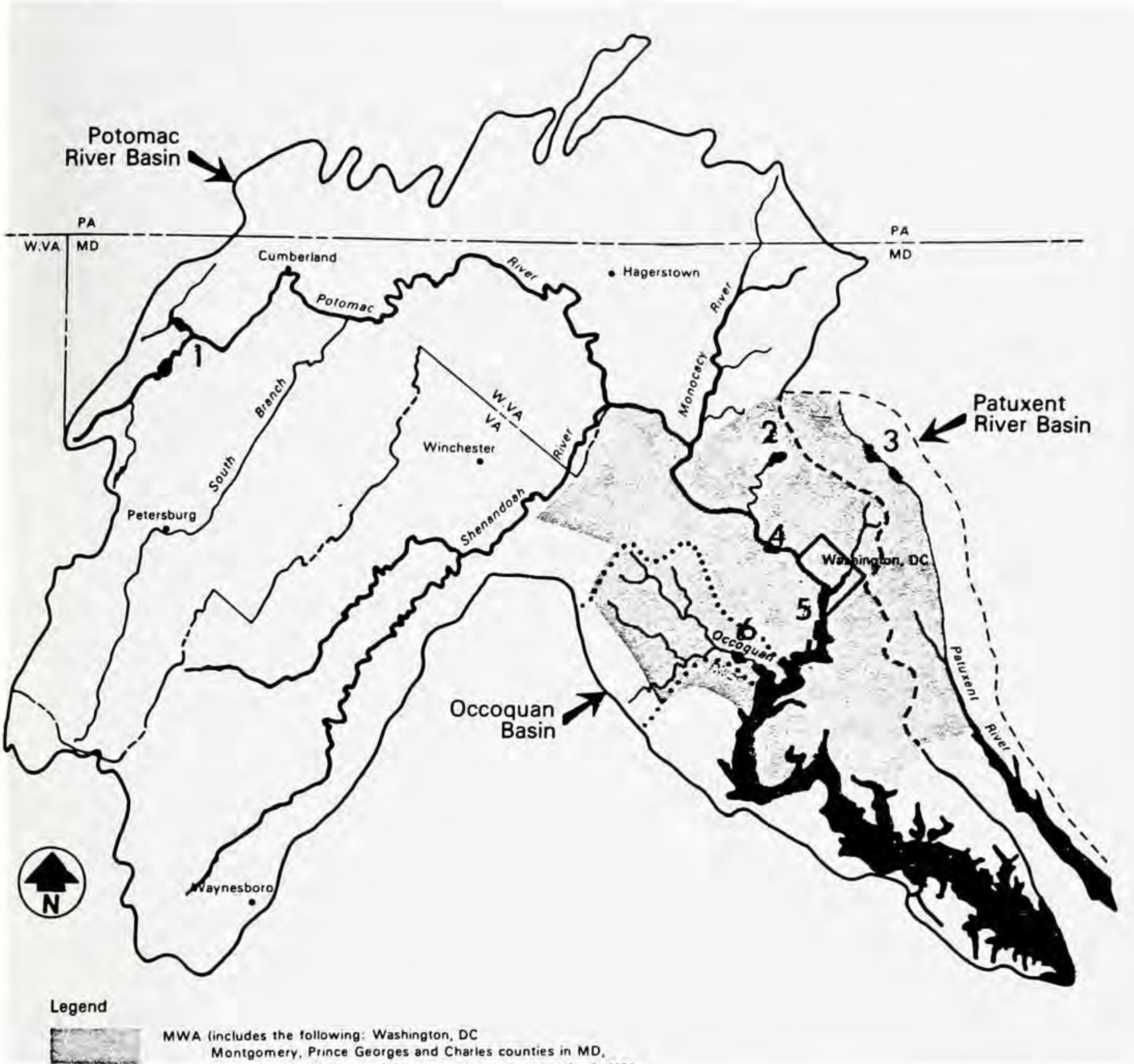
Water interchanges in the District of Columbia area show in chart at right.

basic outline of a drought management program that could meet the future water needs of the Washington area and leave enough left to flow into the Potomac estuary and the Bay without any large upstream reservoirs besides Bloomington and Savage. This plan, using just two instead of sixteen reservoirs indicates that the Corps had not only more exact information and tools for future projects, but that the original plan was conceptually flawed. It would have provided far more water than the Potomac basin actually needed. The new study was coordinated with a broader examination of drought management and water supply conducted by the Corps' North Atlantic Division and also with the aid and advice of all the Washington area water supply agencies. Experts from these water authorities were brought together by the Baltimore District to form the Federal-Interstate-Regional Advisory Board. Even though the name was unwieldy, the advisory board became a key element in the Corps plan since the cooperation of local and state water agencies was essential to its success. The restudy, called the Metropolitan Washington Area Water Supply Study, began in 1975, and the final report was issued in September 1983.[12]

The first phase of the study, conducted in 1975-1979, focused on four matters: (1) completion of Bloomington dam; (2) completion of the design for the 100 mgd pilot estuary treatment plant; (3) recommendations for local expansion of water storage facilities, conservation programs, and interconnection facilities; and (4) negotiation of a low-flow allocation agreement among the water supply authorities in the Washington area.[13] The Corps' first success came with the low-flow agreement. After lengthy negotiations involving the Corps, the District of Columbia, Maryland, Virginia, and the local county governments, an agreement was signed on 11 January 1978.[14] The agreement was based on Corps projections of future water shortages during drought periods. The signers agreed that 100 mgd was needed to continue to flow past Little Falls (beyond the water utility intakes).

The flow-by study was conducted by Maryland in cooperation with the Department of the Interior and other federal, state, and local agencies.[15] Released in the fall of 1981, the study recommended a minimum flow-by of 100 mgd. The figure improved substantially the ability of the Washington area to survive future droughts, but it was attacked by some environmentalists as too low to protect aquatic life in the upper estuary.[16]

In 1979, the Corps made public its revised solutions to the Washington area water problem. The general conclusions were presented at the public workshop in January 1979, and a fuller explanation was published in August.[17] The report stated that Washington area governments could meet their projected water needs, revised in this report, to the year 2030, even under drought conditions as severe as the worst on record, provided that one of several alternative plans of action was taken by the local, state and federal governments. None of the new alternative plans called for the construction of more large up-



1 UPSTREAM RESERVOIRS

- Approximate 7-Day Travel Time to MWA Intakes
- Releases Blended to Improve Water Quality

SAVAGE RESERVOIR

- Total Available Storage - 5900 Million Gallons
- Maximum Release - 3130 MGD

BLOOMINGTON LAKE

- Total Available Storage - 30,000 Million Gallons
- Maximum Release - 10,710 MGD

2 LITTLE SENECA LAKE

- Total Available Storage - 4020 Million Gallons
- Maximum Release - 275 MGD
- Approximate 1-Day Travel Time to MWA Intakes

3 PATUXENT RESERVOIRS

ROCKY GORGE & TRIADELPHIA

- Total Available Storage - 10,100 Million Gallons
- Max. Water Supply Withdrawal - 65 MGD

4 MWA INTAKES

	Maximum Withdrawal (MGD)	Treatment Capacity (MGD)
FCWA	200	50
WSSC	400	240
Rockville	8	8
Aqueduct	650	371

5 ENVIRONMENTAL FLOWBY

Environmental Flowby to the Estuary with a Minimum Value of 100 MGD

6 OCCOQUAN RESERVOIR

- Total Available Storage - 10,300 Million Gallons
- Max. Water Supply Withdrawal - 112 MGD

stream dams after Bloomington. The five plans provided for various levels of intergovernmental cooperation along with a series of nonstructural actions.

Plan Four, providing for cooperation among the Washington area governments and the Corps, appeared to have the best chance of political agreement and would still meet the water supply requirements of the capital region during emergencies. Under this plan, the Washington area water authorities could meet a 1930-1932 level drought (the worst on record) in the year 2030 *provided* they were willing to: (1) expand the current storage capacity of local Washington area reservoir systems by approximately 5 billion gallons; (2) interconnect the individual water systems and operate them as a single system during drought emergencies; (3) carry out a long-term program of water conservation and, during drought emergencies, water restrictions; (4) agree to share the water from Bloomington and Savage dams; and (5) continue the low-flow allocation agreement. The cost of the program would depend on the particular construction alternatives selected.

The Corps recommended building two local water storage projects already under study by local authorities, Little Seneca Creek and Occoquan Upper Dam Expansion Project. Little Seneca Creek reservoir, in Montgomery County, would be a 4.33 billion gallon capacity reservoir. The Occoquan Upper Dam Expansion Project, on the Virginia side, called for increasing the height of this existing dam by 2 feet, which would increase its water storage capacity from 9.1 to 10.5 billion gallons.[18]

In times of severe drought, these two reservoirs, along with the older WSSC reservoirs on the Patuxent River, would form the supply base to augment the interconnections between the Potomac and the finished water systems. The Potomac, of course, would be augmented by releases from Bloomington and Savage dams. Bloomington, Savage and all the local supply reservoirs would be maintained at their maximum levels of water storage to guard against droughts. They could not be kept at maximum pool level because some capacity (in the case of Bloomington a rather large amount) needs to be kept free to hold flood waters.

Even though the Corps report was still incomplete when it was released in 1979, its basic findings and general recommendations were applauded by environmentalists, local government officials, and the public. The Interstate Commission on the Potomac River Basin (ICPRB) said the *Progress Report* offered a "surprising new solution" and was "unlike anything the Corps has done in the Potomac Basin." The report recommendations, it said, "are remarkable in that they represent a new step for the Corps of Engineers, whose water supply studies in the past have followed more traditional approaches."[19] The *Washington Post* praised the report as one which "emphasizes conservation and downplays dam building." The entire approach, it said, represented "a significant shift of policy." This shift, stated a *Post* editorial, was made "through evolution, not a sudden turnabout." The Corps' recommendations put the region's governments "on a course that promises to be much more economical and environmentally sound than damming up the river any more."[20]

Encouraged by the wide acceptance of the *Progress Report*, the Corps called together its Federal-Interstate-State-Regional Advisory Board (FISRAC) in December 1979 to discuss the results of the water supply study up to this point and begin phase two of the study which looked ahead towards a final solution of the issue. As the Corps *Final Report* states, "this FISRAC meeting and the actions stemming directly from it achieved far more than any of its participants envisioned at the time."[21] The participants agreed that on the basis of the analysis presented in the *Progress Report*, the Washington area water supply problem could be solved without any further federal construction of reservoirs, *provided* the local jurisdiction and water utilities cooperate closely in the management of the region's water supply resources. This meant that WSSC and the Fairfax County Water Authority (FCWA) would have to agree to share their water with the District of Columbia and the City of Rockville during drought emergencies. This is what the meeting's participants agreed to in principle. They took the further step of asking retired Brigadier General Robert McGarry, the former Baltimore District Engineer who had become the new general manager of WSSC, to head a task force to turn the general principles of the drought management strategy into a specific plan agreeable to all major parties.[22]

The Water Supply Regional Task Force was created in 1980 with elected officials from Montgomery, Prince Georges and Fairfax counties and the District of Columbia. By the spring of 1982, it had devised a plan that embodied legal, administrative, financial and engineering actions designed to solve the area's water problems through the year 2030. The plan consisted of the following elements:

1. Continuation of the Low-Flow Allocation Agreement and its incorporation into the overall water supply plan with a review every five years to determine fairness.
2. Establishment of a Water Supply Coordination

Agreement between WSSC, FCWA and the Corps of Engineers' Washington Aqueduct to operate their facilities cooperatively under the management on the ICPRB. This is, according to the Corps' *Final Report*, "the cornerstone of the cooperative regional management of the water supply system."

3. Incorporation of the 1979 Water Supply Emergency Agreement of the Washington area local governments (providing for mutually administered water consumption restrictions during drought emergencies and long-term programs of education, metering and plumbing code changes).

4. "Reregulation" of Potomac River water into the Patuxent and Occoquan reservoirs during normal periods so they could be kept at maximum capacity for regional use during drought emergencies.

5. Construction of the proposed Little Seneca reservoir in Montgomery County and an increase in the size of Occoquan reservoir in northern Virginia. The costs and benefits to be shared by all local jurisdictions.

6. The operation of Bloomington and Savage reservoirs not only for the Potomac upstream area, but also for Washington area water supply needs.[23]

As the Water Supply Task Force continued its work in 1980, computer modelers at the Corps' Baltimore District, at the Interstate Commission for the Potomac River Basin and at Johns Hopkins University were at work developing even more sophisticated computer models of the Potomac River and the Washington area water supply system. Previously, it had only been possible to project future water needs in terms of the *rate* of required flow in millions of gallons per day. They developed a mathematical model that replicated the river-reservoir system's operation in terms of the total *volume* of water in the system as well as rates of flow. The Corps was now in a position to examine how all the local Washington area reservoirs plus the upstream reservoirs could be harmonized in their water releases to meet future drought emergencies.

The "capstone" of this research was development of the PRISM/COE system to simulate the entire operation of the Washington area water supply system from the headwaters of the Potomac to the household water taps of the Washington water supply area. PRISM (Potomac River Interaction Simulation Model) was developed by a group at Johns Hopkins University in conjunction with the ICPRB. The Corps modified the PRISM program to fit its needs for the Washington Area Water Supply Study, calling the revised program PRISM/COE (Corps of Engineers). In August 1981, a group from the Corps, Johns Hopkins, local water authorities, and the ICPRB, used PRISM/COE, to simulate the operation of the entire Potomac-Patuxent-Occoquan water systems as it would work in the year 2030 with drought conditions following the pattern of the 1930-1931 and 1966 droughts.[24]

The Potomac and the Washington area water system was operated by managing the releases from Bloomington, Savage, and the local reservoirs (as they would exist in 2030) to provide enough water to meet the drought emergency, day by day, but not more than was necessary at any moment. Studies by the U.S. Geological Survey provided the Corps with the vital information that water released from Bloomington dam reaches the Washington water intakes more quickly than had been previously estimated (47% in the first week and the other 53% the second week). Thus, Bloomington's huge capacity could be used in close conjunction with the local reservoir releases to meet the short-term crises that were the historical pattern of Potomac droughts. The simulation assumed the implementation of all six major recommendations of the Water Supply Task Force as well as the population forecasts of the 1979 *Progress Report*.

The simulated drought and water management response appeared to prove conclusively that the Corps plan could easily meet the drought emergency needs of 2030. Indeed, so precise were the releases from the five reservoirs that at the end of the 1930-1931-level drought simulation, 60% of the system's water supply storage was still available at the end of the drought. An amazing 75% was left after the end of the 1966 drought simulation.[25]

While the Corps and the Water Supply Task Force tested the recommendations with the PRISM/COE system, the major portions of the legal, administrative and technological system were being put in place. In February 1981, all the local area water authorities agreed to jointly finance and operate the proposed Little Seneca reservoir in Montgomery County that was an important key to the drought emergency plan. Its ability to deliver large releases of water very quickly into the water supply system obviated the need to release millions of gallons from Bloomington and/or Savage when, by the time the water arrived at Great Falls (7-14 days later), it might not be required in such quantities or at all. In July 1981, Bloomington dam itself was dedicated, 20 years after the Corps had recommended it. Its 30-billion gallons of water-supply capacity is clearly the foundation and basic water insurance policy for the Washington region. The Corps had already completed its drought emergency water intake facility at Little Falls and in the summer of 1981 began operation of its Potomac Estuary Experimental Water Treatment Plant.[26]

At a historic ceremony on 22 July 1982, the Corps and state and local agencies signed a series of water agreements that implemented the plan developed by the Water Supply Regional Task Force, a plan based almost entirely on the Corps' 1979 recommendations. The agreements provided for sharing the water supply facilities of the entire Washington region following the prearranged water management policies

Hydrilla, an aquatic plant from Asia, is removed from the Potomac after it is mechanically harvested to keep marinas and boat slips open.

during drought emergencies. The ICPRB would play the leading role in providing administrative coordination for the system through its Potomac River Basin CO-OP (Cooperative Water Supply Operations on the Potomac) Program.[27] The greatest single water supply problem in the Chesapeake basin was solved with a minimum of dam building.

The Corps and the Potomac Hydrilla

Another, but quite different problem that has affected the Potomac and has the potential to become a Bay-wide menace, is the growth of huge beds of hydrilla (Hydrilla verticilata), an aquatic plant from Asia that was inadvertently introduced into the Potomac estuary. By 1982, it covered approximately 10 acres of water near Alexandria, Virginia. Hydrilla grows rapidly and is highly competitive with other aquatic plants, displacing them and creating an almost impenetrable bed that makes boating difficult if not impossible. By 1984, the plant had spread to 600 acres and then to 1,900 acres in 1985. It had appeared in patches of varying density from just north of the Woodrow Wilson Bridge to Quantico, Virginia.[28]

Because of its interference with navigation, the states of Maryland and Virginia asked the Corps of Engineers in 1984 to study the problem and recommend a solution. It was not clear that there was a solution, or if there was, whether it would be cost-effective or environmentally sound. The Baltimore District plotted the pattern of hydrilla growth in the river, examined the growth patterns and management policies practiced in Florida, where hydrilla has been a problem since the 1960s, and contracted for research studies of the plant by the Corps' Aquatic Plant Control Research Program at the Waterways Experiment Station.[29]

The district's report and environmental impact statement, issued in February 1986, indicated the hydrilla would continue to spread in the Potomac at a rate that would cover approximately 36,000 acres by 1995. This would interfere with an increasing number of navigation channels and affect the environment of the entire upper estuary. The environmental effects, however, could not be accurately predicted. While the hydrilla crowded out other types of native aquatic plants, it did appear to provide a good habitat for several species of fish and water birds. A number of people in the Potomac region, having watched for so many years as all types of submerged aquatic vegetation (SAV) disappeared, were opposed to any all-out attack on the plant. On the other hand, boaters were finding it impossible to get out of their marinas or boat slips.[30] Whether hydrilla was friend or foe clearly depended on one's point of view. When the Corps began its study there was no clear evidence that any major effort to keep open the 28 marinas and boat ramps in this part of the estuary was cost-effective.

A number of methods of controlling hydrilla were examined. The introduction of the grass carp (native to the Amur basin of Eastern China) into areas infested with hydrilla had proven successful in other areas of the United States, but the problem with these fish was that they not only ate the hydrilla, but other submerged aquatic plants also, and might deplete the entire aquatic plant population in the upper estuary. The most widely used method to control hydrilla is the herbicide Diquat. However, since most hydrilla control programs using Diquat have been in waters with less turbidity and lower flow velocities than the Potomac, the use of the herbicide in this instance was thought by the Waterways Experiment Station experts to be questionable. There were also objections from both Maryland and Virginia water officials to the use of the herbicide.[31]

Mechanical harvesting was clearly the least environmentally intrusive, but it was initially thought to be too expensive. However, after detailed study and experimentation, it was found that a program of mechanical harvesting, limited to keeping only the channels to the marinas and boat slips open, was actually less expensive than the use of Diquat. It would require cutting about 290 acres of hydrilla twice each summer. An analysis of the benefit-cost ratios showed the channel cutting program was indeed very cost effective, with a ratio of 9.2 to 1.0, or $2,544,000 in annual benefits, compared to $276,000 in annual costs. This portion of the study provided a revealing glimpse of the economic importance of boating in the Potomac estuary.[32]

In 1986, Baltimore District Engineer Colonel Martin W. Walsh, Jr. decided to undertake a controlled harvesting program for the hydrilla. It will not be eliminated or even contained. Elimination or containment of the hydrilla, while strongly urged by boating interests, was not a decision the Corps felt it should make. Its obligation to maintain navigation did not require such an action, the environmental impact of a major attack on hydrilla was not yet possible to estimate, and there was presently no cost-effective way of achieving the goal even with Diquat. Other chemicals such as Endothal and copper complex herbicides that were less expensive were ruled out by the Corps because they had not been approved for use by EPA or the state of Maryland in the free flowing waters of the Potomac River.[33]

The solution recommended by Colonel Walsh was accepted by both Maryland and Virginia. The governors met on 6 June 1986 at Mount Vernon and

signed a joint agreement with the Corps to pay their share of the harvesting program. By this time the hydrilla covered over 3,000 acres of the Potomac so the two governors could look out over the river and see patches of the aggressive weed right in George Washington's front yard.[34] The harvesting program will at least allow boaters to get out into the river until the rate of growth and the various impacts of the hydrilla are better understood.

The Corps and the Susquehanna River Basin

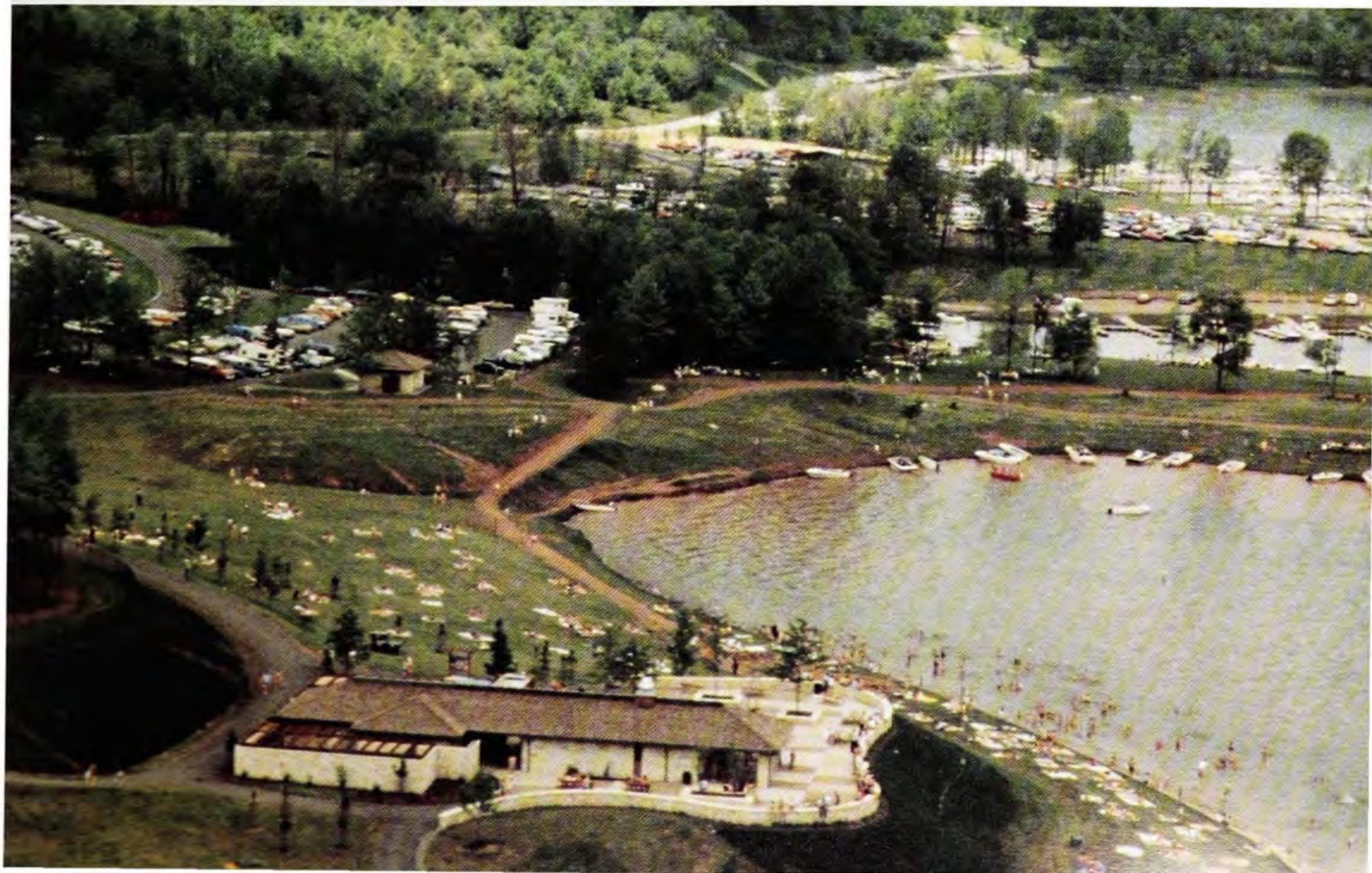
The average flow of the Susquehanna into the Chesapeake each spring is 75,000 cfs, more than three times the flow of the Potomac. In the fall, the Susquehanna average flow drops to 20,000 cfs, or just under one third of its spring flow. Ten percent of the time its flow drops to approximately 7,000 cfs. This is a more even flow pattern than the Potomac, but it has

The municipal water supply problem on the Susquehanna basin is not as serious as the one on the Potomac because it has no metropolitan area as large as Washington.

Harrisburg, (upper right) with a population of 430,000, is the largest metropolitan area in the basin. Dams built on the Susquehanna by the Corps primarily provide flood control, but they have other benefits such as recreation, (right) water supply and, in some areas, abatement of acid mine drainage.

not allowed the Susquehanna to escape from serious water supply difficulties during low flow periods.[35]

The nature of the water supply problems in the Susquehanna basin differs significantly from those in the Potomac. The municipal water supply problem is not as serious as the one on the Potomac because there is no metropolitan area in the Susquehanna basin to compare with Washington. The Harrisburg Standard Metropolitan Statistical Area (SMSA), with a population of 430,000, is the largest in the basin, but compared to the Washington SMSA of 3 million people, is fairly small. Indeed, the total population of the Susquehanna's six metropolitan areas is only 1.1 million, and none is expected to grow significantly during the next three decades. The more significant water withdrawals in the Susquehanna basin are for



industrial use, power plants and irrigation.

On the other hand, the Susquehanna basin has periodic oversupplies of water that are far, far more damaging than its droughts. The Susquehanna basin has a flood problem among the worst in the nation. It was the scene of several of the nation's most damaging floods (the 1972 tropical storm Agnes flood caused over $3 billion in damages). Beginning in the 1930s, Congress directed the Corps to construct a large system of reservoirs in the basin. To date, 13 reservoirs have been built by the Corps in the Susquehanna basin primarily for flood control, but they have other benefits such as recreation, water supply and, in some areas, abatement of acid mine drainage. For example, 10 of the dams have recreational facilities visited by a total of approximately two million people a year.[36] The four dams on the West Branch of the Susquehanna are operated as an integrated system to dilute ''acid slugs,'' large surges of very acidic waters that are occasionally washed out of the thousands of abandoned coal mine shafts in the area. The West Branch acid dilution program offers, incidently, a classic case of environmental trade-offs, since the drawing down of the West Branch reservoirs to improve water quality of the West Branch River hurts fishing and recreational activities at these reservoirs. Tioga reservoir, which is extremely acidic due to mine drainage, is linked by an underground tunnel to nearby Hammond reservoir which is fed by highly alkaline Crooked Creek. Hammond is maintained with a higher pool than Tioga, so when water is released from Tioga, it has been mixed with Hammond's water to reduce the acidity.[37]

In spite of the very large dam building program of the Corps in the Susquehanna basin (13 of the 16 dams in the whole Chesapeake watershed are located

Raystown (left), one of 10 reservoirs built by the Corps on the Susquehanna that provide recreational facilities visited by about two million people a year. Thirteen of the 16 dams in the whole Chesapeake watershed are located on the Susquehanna.

there), major current and future water supply needs in the basin are not yet satisfied. During periods of low flow there is a need for municipal and industrial supply, power plant cooling, agricultural irrigation and flow augmentation to dilute acid main drainage. These withdrawals are expected to increase in the future. There is also clearly a need to augment the flow of the river into the Bay since, as the Corps Low-Flow Study and the EPA Bay Study indicated, periods of prolonged low flow increase salinity levels in many parts of the Bay and appear to contribute to increased oxygen deficiency (euthrophication), algae blooms and lack of oxygen (anoxia) in deep waters. Marine scientists believe these conditions are associated with the decline of many aquatic species in the Bay, with accompanying losses to the commercial fishing industry as well as sport fishing.[38]

In response to a 1961 resolution of the Senate Public Works Committee, the Corps directed a joint federal-state study of the Susquehanna River basin, and in June 1970, published a 21 volume report entitled the *Susquehanna River Basin Study*. The report included a long-range water resources development plan for the entire basin. It recommended an "Early Action Plan" and a longer-range "Framework Plan" to deal with the problems of flood control, water pollution, water supply, hydropower and recreation. While the Susquehanna River Basin Study was moving forward during the 1960s, representatives from Pennsylvania, New York and Maryland formed a committee which drew up a Federal-Interstate Compact for the Susquehanna basin to coordinate water resource programs of federal, state, local and private interests. A Susquehanna River Basin Commission was created by Congress and signed by President Johnson in December 1970. Almost the entire list of Corps recommendations was adopted by the commission in its "Comprehensive Plan" of 1973.[39]

Unfortunately, a number of the Corps recommendations for multi-purpose reservoirs and local flood control projects ultimately proved to be too expensive while others lacked local support. The "Early Action Plan" recommended five additional reservoirs in the basin in addition to the thirteen already in existence or under construction. The new reservoirs would be primarily for flood control but also for water supply, pollution abatement and economic development. Three of the five suggested projects were studied by the Corps between 1970 and 1974 and found to be uneconomical. The other two were strongly opposed by local residents and were not pursued.[40] Following the massive flood destruction caused by tropical storm Agnes in 1972, the Baltimore District again reviewed all possible sites where multi-purpose reservoirs might be built, but was forced to report in 1980 that none was economically justifiable, a conclusion that deeply disappointed leaders in the Susquehanna basin.[41] The Baltimore District found itself in the somewhat unusual position of being criticized for not building enough dams.

This anomoly arose from the fact that the two river basins have significantly different water resource problems and radically different demographic and economic structures. The Potomac basin is polarized between the Washington, DC metropolitan area which holds over three quarters of the entire basin population, and the upstream area which contains the most attractive reservoir sites. The most simple and cost-effective way to supply the Washington area with an abundance of water is to build two or three large multi-purpose reservoirs on Potomac tributaries; but this was perceived by local residents in the upstream areas to be an unfair burden. Environmentalists, who in this case opposed the whole concept of large multi-purpose dams, joined local residents to form a very powerful political bloc which forced the Corps and Washington area local governments to find a local solution to the Washington water problem without the construction of any more large reservoirs. In the Susquehanna basin, the population is much more evenly distributed in a large number of small and moderate size towns and cities—almost all of which have very serious flood control problems and stand to gain from the construction of large multi-purpose reservoirs. There are also some locally serious water supply problems, but they are again distributed across the basin and do not polarize political opinion. Opposition to large dams arises only in a few areas of the basin such as Western New York where local residents opposed dams that were of little value to them, but which would reduce flooding downstream in Pennsylvania. Also, there has not developed in the Susquehanna basin any basin-wide environmental movement opposed to large dams such as arose in the Potomac basin. Unfortunately, the rising costs of reservoir construction and the declining value of the old industrial towns in the Susquehanna basin made it impossible for the Corps to find sites for reservoirs that met the federal guideline for cost-effective

projects. Political leaders in Pennsylvania and New York were not influential enough to alter the government benefit-cost formula. Therefore, the Corps found itself in the position of being pressured by residents of the Susquehanna basin to build just the type of large dams that had been so loudly opposed by residents in the Potomac basin.[42]

The federal government has not altered its cost-benefit calculation system, but the situation has changed somewhat in the years since 1980. The major new element is the increasing interest of water users in the storage capacities of the Susquehanna reservoirs already in existence, and also those that might be constructed in the future. The most interesting aspect of the issue is the possibility of managing the storage capacity of the Susquehanna's existing reservoirs not only for water users along the Susquehanna, but for those who might be willing to pay to keep the river flowing at a higher rate into the Chesapeake, to maintain its supply of commercially valuable seafood and to enhance recreational opportunities. This has given a new impetus to the study of the uses to which the water stored in existing reservoirs can be used, how their storage capacity might be increased, or whether one or more new reservoirs might not be cost effective.

The Baltimore District began to study the reformulation of storage capacities in its existing reservoirs in the Susquehanna basin in 1979, when it was asked by two power companies and the Susquehanna River Basin Commission to study the feasibility of reallocating some of the flood control storage at Cowanesque Reservoir to water supply storage—an action that would also require raising the pool level in the

reservoir. Downstream users, power companies and other industries, would use the new storage capacity for replacing water they would take out of the river and not return. The Susquehanna River Basin Commission requires that during specified periods of low flow in the basin, water users either refrain from taking water from the rivers or replace all water lost through consumptive use. The costs associated with the changes at Cowanesque to provide water for this purpose would be borne by the downstream users.[43]

A preliminary hearing in 1980, on the Cowanesque Lake Reformulation Study, as it was called, indicated local fears that the maintenance of a larger pool for water supply would make Cowanesque much less effective for flood control. Environmental groups such as the local Audubon Society feared that major fluctuations in the reservoir pool would harm wildlife in the reservoir area, while recreationists thought that summer drawdowns of the reservoir would lessen fishing and boating activity. Anti-nuclear energy groups objected to the use of a portion of the water supply by nuclear power plants along the river.[44]

Reallocating some of the flood control storage to water supply storage at Cowanesque Reservoir requires raising the pool level in the reservoir. The plan for reallocation was supported by the town of New Nelson.

Supporters of the project included water-supply officials and industrial users who thought the need for better water supply sources outweighed the negatives. A significant factor in the debate was the fact that power companies and other downstream users, who were required to return to the river as much water as they withdrew, were willing to buy water from Cowanesque reservoir. This allowed the federal government to obtain a cash return on its huge investment in Susquehanna basin dams.[45]

Because local residents showed so much concern over the reformulation proposal, Colonel James W. Peck, the Baltimore District Engineer, met in June 1980, with local citizens and officials and agreed to form a local citizens group to study the question and advise the Corps. The group held a number of meetings with representatives from the Corps, other federal agencies, and state and local water resource departments, but did not alter its initial negative view. While recognizing the power companies' need for water, the advisory group thought these requirements could be met by having them construct their own smaller private reservoir.[46] The Corps issued its draft report, which recommended raising the reservoir to 1,080 feet. This was not the most cost-effective pool level, but it was still economically justifiable and would meet the water needs of downstream users "without significantly affecting the project's flood control or recreational purposes."[47] Basically, the reformulation proposal pitted the local residents against the power companies, the SRBC, the states of Pennsylvania and New York, and the Corps.

The one surprising exception to local opposition was the town of New Nelson, a small village formerly called Nelson, Pennsylvania, that had been relocated due to the construction of Cowanesque reservoir. Having been the ones to pay the greatest price for the installation of the original project, the townspeople thought it was narrow-minded of other local residents, who were much less disrupted by the reservoir, to

deny water to downstream users just because they wanted to keep the reservoir as it was when originally built. Once the dam was built, argued the spokesmen from New Nelson, it should benefit as many people as possible by achieving its full potential.[48]

In the spring of 1982, the Baltimore District Engineer recommended the so-called "1080 Plan," but more detailed studies were conducted in 1983-1985, comparing the costs and benefits of various pool levels at Cowanesque with those that would arise if the two power companies constructed their own reservoir at the site they had identified as the best they could find. Raising the Cowanesque pool by 35 feet (to 1080) and reallocating a larger portion of this storage capacity to the power companies, proved to be more cost beneficial even with the Corps' requirement that the companies repay an allocated share of the original cost of the project. Cost-sharing contracts between the Corps and the power companies are currently being negotiated.[49]

The success of the Cowanesque reformulation study led the Baltimore District to do a limited reconnaissance study to identify existing and potential multipurpose reservoir projects throughout the Chesapeake basin, which could provide cost-effective water resource benefits to the Chesapeake Bay and its basin, through reallocation of existing storage capacity, creation of additional storage, and system management of various combinations of reservoirs. The study examined the Chesapeake's four major river basins (the Susquehanna, Potomac, Rappahannock and York). A reallocation study for Bloomington dam in the Potomac basin had already been conducted as an outgrowth of the Washington area water supply study, so it was not necessary to repeat it. The York basin showed no possibilities worth pursuing at the time. The Rappahanock basin had one potential reservoir site (Salem Church) which is currently not an active project due to lack of local support. The limited reconnaissance study, however, indicated it was worthwhile to reevaluate this project in more detail and assess the advisability of additional multipurpose projects in the basin.[50]

Therefore, with the exception of the relatively small-scale study in the Rappahannock basin, the Susquehanna basin provided the major focus of the limited reconnaissance study in 1987. The Baltimore District planners first looked at reallocation of storage capacity from the existing federal reservoirs. Of the 12 reservoirs in the Susquehanna basin (excluding Cowanesque which had already been studied), 10 had conservation storage in addition to their flood control storage. The total conservation storage at the 10 reservoirs was 622,000 acre-feet (the quantity of water required to cover one acre to a depth of one foot, which is equivalent to approximately 326,000 gallons). Approximately 472,000 acre-feet of this storage could be reallocated for water supply and/or low-flow augmentation. The great majority (87%) of this storage is in the Corps' Raystown Lake project, the largest reservoir in the Chesapeake basin, and one of the Pennsylvania's most popular water-related recreation areas. It was also determined from detailed studies of Cowanesque and Bloomington reservoirs that approximately 320,000 of the 836,000 acre-feet of flood control storage at the Susquehanna reservoirs could be reallocated to other uses with only a 5% loss of flood control benefits. Approximately 83% of this storage comes from five reservoirs (Raystown, Curwensville, Tioga-Hammond, Alvin R. Bush and Whitney Point). This total storage of 792,000 acre-feet, if devoted to low-flow augmentation, could maintain the flow of the Susquehanna at approximately 6,500 cfs during periods when the natural flow plus consumptive losses would otherwise reduce the flow below this level. However, a constant flow augmentation would not be standard procedure, since variable flows during the four seasons would be more supportive of a balance ecological system for both the river and the Chesapeake Bay.[51] By requiring downstream (or

The Corps' Raystown Lake project is the largest reservoir in the Chesapeake basin and one of Pennsylvania's most popular water-related recreation areas.



Chesapeake Bay) users of this storage to pay an allocated portion of the original construction cost of the six dams providing the storage, up to $387 million in federal dollars invested in these projects could be recovered.

Based on an analysis of the limited reconnaissance study, the Baltimore District Engineer recommended a full reconnaissance study of six of the Susquehanna basin's reservoirs be made for reallocation and that five sites previously examined in the course of the *Susquehanna River Basin Study* and the *Flood Control Review Study* be reexamined in light of the new potentials for use of their storage capacities. In addition, it was recommended that a detailed analysis be made of the systematic management of water releases from all federal and (larger) non-federal reservoirs in the Susquehanna basin. The remarkable success of basin-wide water release management in the Potomac basin provided firm evidence such a system in the Susquehanna could result in substantially greater benefits at lower cost. These recommendations were approved by the Chief of Engineers and the Assistant Secretary of the Army for Civil Works. This study will cost $4,453,000 and will be paid for entirely by the federal government. The next phase, a detailed feasibility

Five sites will be reexamined in light of new potentials for their storage capacities. Flood control storage at Curwensville (left), Alvin R. Bush (left, center), Tioga-Hammond (left, below) and Whitney Point (below) together with Raystown (previous page) could be reallocated for water supply and/or low-flow augmentation.

study, will be shared 50/50 by the federal government and non-federal sponsors who will benefit from the proposed action.[52]

The limited reconnaissance report raises the possibility of ultimately operating all the federal and non-federal reservoirs in the entire Chesapeake basin as an integrated system. The PRISM/COE program developed for the Potomac is certainly capable of expansion to the other river basins of the Chesapeake, but the development of the data required to simulate the flows of the entire Chesapeake watershed is a very large project. It would involve a great deal of expensive data collection, and it is not yet clear whether such a task would be cost beneficial. Undertaking this task for the Susquehanna basin is undoubtedly cost beneficial and that is why the Assistant Secretary of the Army for Civil Works approved the full reconnaissance and feasibility phases of this part of the study. It will give the people of the Susquehanna basin a grasp of the water resource management potentials of their basin that residents of the Potomac basin have enjoyed now for almost a decade. It will also bring the entire Chesapeake Bay water system a step closer to the development of a Bay-wide watershed management policy.

Chapter VII
Shorelines and Wetlands since the Chesapeake Bay Future Conditions Report, 1977-1987

In the years between the passage of the National Environmental Policy Act in 1969 and the establishment of the Chesapeake Bay Program in 1983, the major problem areas of the Bay have been more clearly defined and an increasing number of actions have been taken to address them. The Bay's shoreline, marshes and wetlands are certainly areas where this has occurred. Maryland passed its major wetlands protection act in 1970, and Virginia passed similar legislation in 1972. Both states have also passed legislation to address shoreline erosion. Maryland provides 50/50 matching grants for private landowners to plant erosion-retarding vegetation along their shorelines, and it also has a program of grants to local governments for several types of shoreline improvements on public lands. Virginia has developed programs of a similar nature. Maryland took a further step in 1984, when it passed the Chesapeake Bay Critical Areas Protection Act, authorizing the state to (indirectly) control land use on a strip 1000 feet wide adjacent to the entire Maryland portion of the tidal shoreline in order to minimize adverse impacts on water quality. A state-level Critical Areas Commission has established general criteria and guidelines for land use in the critical area. Each local jurisdiction adjacent to the Bay is responsible for implementing the commission criteria in its local area and was required to submit a plan to the commission by December 1987.[1]

The Baltimore District has also been working towards this goal for a number of years. It has constructed shoreline erosion protection devices at the many Bay-side federal facilities since the late 19th century and has been involved in a broader program of erosion control since 1946. Since 1983, it has been the lead agency in a congressionally authorized Bay-wide erosion control study program. The district's permit program touches almost every property owner and local government having property on the Maryland portion of the Bay, its tributaries and their adjacent wetlands. The Norfolk District exercises similar authority in the Virginia portion. The erosion and permit programs make the Corps a major force in determining the future of the Bay's shoreline areas.

The Baltimore District's permit program touches almost every property owner and local government having property on the Maryland portion of the Bay, its tributaries and their adjacent wetlands.

While nature is the major cause of shoreline erosion, man-made stuctures can also cause considerable local damage. Tall Timbers, Maryland (below) is a major example. A shallow nearshore (bottom of page) dissipates more wave energy than a deeper one.

Baltimore District Shoreline Erosion Program

The Chesapeake Executive Council identified the protection of Bay shorelines and wetlands as one of its major goals. The CEC's Chesapeake Bay Restoration and Protection Plan of 1985 lists these items under the general heading of the enhancement of the Bay's living resources and their habitats. The reduction of

shoreline erosion also falls under the CEC's goal of reducing sedimentation.[2]

The federal government has been active in assisting the private sector in shoreline erosion control since 1946. The Flood Control Act of 1946 authorized, in sections 14 and 103, several types of aid to public and non-profit groups to protect their shorelines with the cost shared 50/50 between the federal and non-federal participants. The first comprehensive Corps study of shoreline erosion in the Bay was conducted in 1970-1973 as part of the "future conditions" phase of the Chesapeake Bay Study.

There was no question that erosion was a serious problem at many different locations around the Bay in the 1970s. At a number of locations the shoreline had been receding at 10 or more feet per year! Large storms washed away shorelines so fast that houses fell into the water before their owners could do anything about it.

While nature is the major cause of shoreline erosion, man-made structures can also cause considerable local damage. Occasionally, even Corps of Engineers' projects have inadvertently caused such problems. The one major example in the Baltimore District's portion of the Chesapeake Bay is the Tall Timbers shoreline along the lower Potomac River in St. Mary's County, Maryland. Just north of the Tall Timbers residential development is Herring Creek, a popular harbor for private yachts and small commercial fishing boats. The inlet to Herring Creek constantly shifted and shoaled, caused by the eroding sand moving southward across the inlet. In 1958, Congress authorized improvements for the harbor consisting of an entrance channel, protected by stone jetties on each side of the channel, and a turning basin inside the creek. The project was completed in 1961.

The jetties worked very well for navigational purposes, but they also impeded the lateral movement of sand for some distance south of the inlet causing the beach at Tall Timbers to erode at a much more rapid rate than ever before. The Corps had stated that some erosion could be expected, but the actual rate exceeded its predictions. The beach gradually disappeared and storms pushed waves directly onto the bulkheads which residents had built to protect their fastland. In 1972, tropical storm Agnes destroyed a number of the bulkheads, and the erosion problem became far more serious.

The Corps rebuilt the bulkheads for the Federal Office of Emergency Preparedness. In 1982, the Corps initiated a study of the problem under the authority of Section 111 of the 1968 River and Harbor Act (PL 90-483) which authorized the Corps to construct shoreline protection structures in areas damaged by federal navigation projects. A number of alternative solutions to the problem were considered. A stone revetment was found to be the most feasible method of correcting the problem, so this alternative was recommended by the Corps and approved by local authorities. The structure was completed in 1987 and has ended further erosion along the fastland.

Nevertheless, two other problems arose even from this solution. First, the detailed Corps investigation of the shoreline concluded that only part of it, the section extending approximately 2,500 feet from the inlet, had eroded as a result of the jetties and therefore qualified to be protected under the Section 111 authority. Further south, the shoreline had also eroded, but the Corps concluded that this was due to the natural movement of the Potomac's currents, not the jetties. Local residents along this stretch of shoreline were understandably disappointed and questioned the accuracy of the Corps study. The second controversy arose when the final cost of the revetment, originally estimated by the Corps to be approximately $950,000, came to $1,316,000 and resulted in considerable confusion over who should pay the final cost.

While the situation at Tall Timbers is fairly unique, the project is illustrative of the complex issues involved in protecting a heavily used shoreline in which a variety of factors exacerbate the erosion process and where the cost of mitigating the original problem is difficult to estimate. However, for those local areas willing to make a large expenditure, the Tall Timbers project provides an excellent example of how a shoreline can be adequately protected even against the combined forces of man and nature.

Another problem resulting from shoreline erosion that gained much less attention in the 1970s, was the washing of sediments into the Bay. This aspect turned a local land-use problem into a Bay-wide water quality issue. Thousands of tons of coastline soils were often carried by currents into other locations where they filled channels, smothered oyster beds, submerged vegetation, and added to the load of suspended sediments in the water column, causing impacts on a wide variety of aquatic organisms. Attempts to arrest the rate of shoreline erosion often proved ineffective or counter-productive because of incorrect design and/or faulty construction. When the Bay study was begun it was not known just how serious the problem was around the Bay or how best to deal with it. These were not easy questions to answer, but the Corps appeared to be the most appropriate agency to take on this task. From the time it began constructing coastal fortifications in the Bay in the early 19th century, the Corps had gained a great deal of first

hand knowledge of the very complex processes that built up and eroded shorelines. During the course of the Bay study, the Baltimore District examined the erosion problem along the entire 7,325 miles of Bay shoreline, defining its scope and nature more precisely than had ever been done before and setting the stage for more effective remedial action.[3]

Hydrologists and oceanographers admit that the causes of shoreline erosion are not completely understood. The primary processes responsible for erosion are wave action, tidal currents and groundwater activity. The primary cause of erosion in the Chesapeake is wave energy. The amount of wave energy that reaches the shoreline is dependent on the velocity and direction of the winds and the slope of the nearshore. A shallow nearshore will dissipate more wave energy than a deeper one. Other factors that will dissipate wave energy are offshore shoals (natural or man-made), tidal flats, and submerged aquatic vegetation. Waves associated with hurricanes or other large storms, especially if they occur during unusually high-tide periods, can raise the water levels in parts of the Bay to much higher levels than normal, which allows the steep, destructive storm waves to attack land of higher elevation that is not ordinarily vulnerable.

Erosion from tidal currents is most common in the Bay in constricted areas such as inlets to lagoons or entrances to harbors; but tides are a factor along many miles of Bay shoreline because they change the level at which waves attack the beach, thereby aggravating the basic wave energy problem. An additional issue connected with erosion in more constricted areas of the Bay is wave action generated by ship wakes. In areas such as deeper draft harbor entrances or the approach channels to the C & D Canal, some observers believe this wake activity has increased the natural rate of shore erosion, but there is not yet any conclusive evidence as to how much the annual erosion rate is increased. Another contributing factor on certain reaches of shoreline is the seepage of groundwater through the fastland and into the exposed shore zone. On shorelines with high banks, such as those in Calvert County, Maryland, water percolates downward through porous soils and flows out through exposed bank faces, often eroding bank materials. This process is accelerated where man has removed the natural ground cover vegetation on land adjacent to the banks, thus increasing the amount of rainfall seeping into the ground. A more common man-made cause of erosion is poorly designed jetties or groins out from shoreline that interfere with the lateral movement of sand required for the natural replenishment of beaches and nearshore areas.

Another factor causing shoreline loss is the rising water level of the Bay, which is simply part of the worldwide elevation in the level of the oceans. Much remains to be learned of this global phenomenon, but evidence of it in the Bay is clear. Records of the readings on the tide gauge at Fort McHenry in Baltimore harbor between 1902 and 1962 indicate a rise

On shorelines with high banks, such as those in Calvert County, Maryland (below), water percolates downward through porous soils and flows out through exposed bank faces, often eroding bank materials. This process is accelerated when natural ground cover is removed from land adjacent to the banks, increasing the amount of rainfall seeping into the ground.

in the mean sea level in the harbor of slightly more than 7 inches. On the Eastern Shore where thousands of acres are just a few feet above mean tide, such a change can have tremendous impact.[4]

The rising level of the Bay is a problem that cannot be effectively dealt with at the present time, but many other causes of shoreline erosion can be addressed by a combination of actions that include the constructing of erosion-arresting structures, planting aquatic and terrestrial vegetation, or non-structural solutions such as zoning regulations. The major difficulty is proper diagnosis. Each stretch of shoreline has a unique set of water and land conditions. Along a single mile of Bay shoreline, there may be numerous combinations of fastland, shoreline, nearshore, wave action and tidal currents, each of which calls for a slightly different erosion defense system.

The main goal of the Baltimore District in the "future conditions" phase of the Bay study was to identify the critical areas of shoreline erosion. Areas were defined as critical if they met or exceeded one of two criteria: 1) the erosion rate amounted to 3 or more feet per year, or 2) the erosion rate was 2 or more feet per year, and the current adjacent land use was intensive, i.e., residential, commercial, or industrial. Information on erosion rates was obtained from the Maryland Geological Survey and the Virginia Institute of Marine Sciences. Historical rates of erosion for each area of the Bay were projected into the future, so those that had been eroding at 3 or more feet per year automatically fell into the category of "critical" shoreline. Information from local planning officials was analyzed to project future conversion of shore-adjacent land from open area to intensive use, and these areas were designated "critical" if they were eroding at 2 or more feet per year. This procedure indicated that 402.4 miles of Bay shoreline, 259.5 in Maryland and 142.9 in Virginia, were in the critical category.[5]

Funding limitations prevented more detailed study of the critical shoreline areas, but the sharpened focus which this section of the 1977 *Future Conditions Report* brought to the problem eventually led to further congressional action. In 1983, the U.S. Senate Committee on the Environment and Public Works, at the urging of Bay area leaders, authorized the Corps to study shoreline erosion in the Bay in greater detail and to identify economically sound measures for the protection of eroding areas.[6] The Reconnaissance Phase of the Chesapeake Bay Shoreline Study was conducted between October 1984 and March 1986. In April 1987, funding was made available for the Feasibility Phase, which is being conducted with joint federal-state financing and personnel. It will provide a new level of comprehensive federal-state effort to control erosion in the Bay.

The Baltimore District began the reconnaissance study with data it developed from the shoreline erosion section of its Chesapeake Bay Study. This data was supplemented with new material that had been collected by the U.S. Geological Survey and by the states of Maryland and Virginia. The district's Planning Division then made a new analysis of all the cartographic materials and all previous studies of the Bay shoreline. Some of the map series, such as the original charts of the U.S. Coast and Geodetic Survey, date from the 1850s. The Maryland Geological Survey had conducted a detailed survey of the shoreline in 1947, which was updated during the 1970s. In Virginia, the Virginia Institute of Marine Science also updated shoreline maps in the lower Bay. A total of 7,235 miles of shoreline (4,406 miles in Maryland, 2,919 in Virginia) was studied from the map series to provide an estimate of erosion rates.

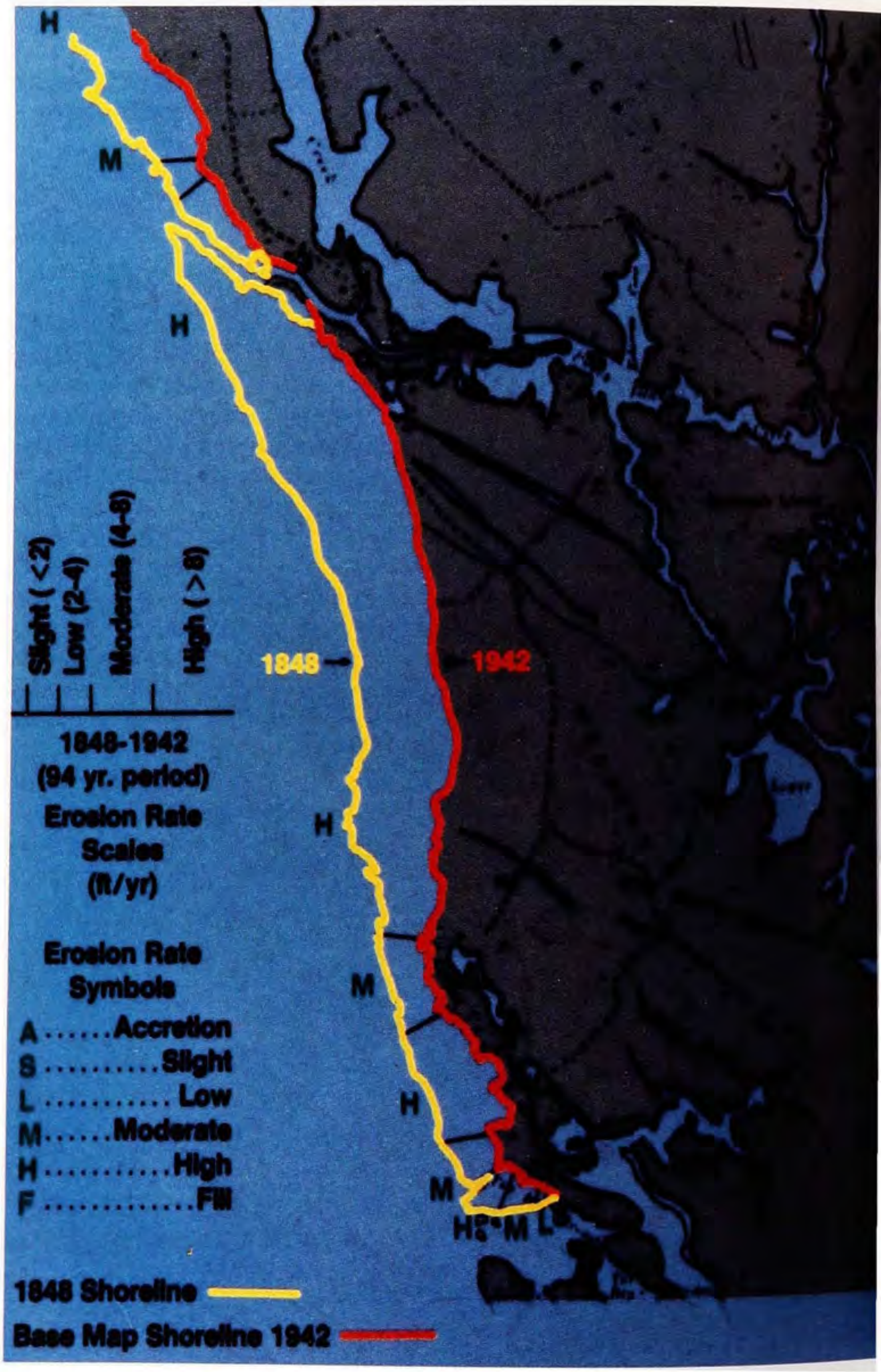
This preliminary historical analysis provided the first figures on erosion rates and identified those shoreline sections requiring more detailed study. The analysis showed, for example, that in the Maryland portion of the Bay, 16% of the shoreline showed some accretion, 61% had slight erosion (0-2 feet per year), 14% had low erosion (2-4 feet per year), 5% had moderate erosion (4-8 feet per year), and 4% had high erosion (greater than 8 feet per year).[7] When translated into miles of shoreline, the figures take on a more concrete meaning. The 9% of Maryland's shoreline eroding at moderate or high rates (4 feet per year or more) represents 396 miles of shore.

In addition to delineating the loss of shoreline around the Bay, the reconnaissance study also calculated the volume of material washed into the Bay by the annual cycle of erosion. This was done to gain an estimate of the contribution that shoreline erosion makes to the total volume of sediment added to the Bay each year. The amount added from the Bay's rivers has been estimated on a monthly basis by the U.S. Geologic Survey for a number of years, but no one had attempted to estimate erosion-generated sedimentation.

To obtain the volume of erosion-generated sedimentation, the Corps calculated the annual loss of fastland for each section of shoreline and then added the amount of loss from the nearshore bottom out to a depth of 8 feet. It was determined that this was the outer edge of erosion that moved sediments into the Bay. The Virginia Institute of Marine Science shoreline survey had already calculated the loss of fastland volume for every section of Virginia's shoreline so the Corps needed only to calculate the loss of nearshore

bottom. In Maryland the fastland volume loss had not been studied by the Maryland Geological Survey, so in addition to calculating the nearshore erosion volume, the fastland loss had to be determined. The Corps examined the topography of the fastland and the nearshore for each section of shoreline to create a profile. Assuming that the eroding shore maintains approximately the same profile as it erodes, the annual volume of materials washed into the Bay was estimated as the vertical distance between the top of the fastland to the outer edge of nearshore erosion (8-foot depth) multiplied by the annual distance of horizontal erosion loss of the profile and the length of the measured shoreline.[8]

Original charts of the U.S. Coast and Geodetic Survey date from the 1850s. The Maryland Geological Survey conducted a detailed survey of the shoreline in 1947, which was updated during the 1970s.



A second analysis was made to eliminate from further consideration all shore sections with erosion rates of less than 2 feet per year unless that reach of shoreline produced a volumetric loss greater than 2 cu. yd. per linear foot per year. This was done because shorelines with erosion rates of less than 2 feet per year (or 2 cu. yd. of volume) were clearly not going to be controlled by any strategy that would be cost effective. This criteria eliminated just over three quarters of the Bay shoreline, allowing the Corps to concentrate on the remaining 1,800 miles that was eroding, but cost-effective solutions for all these segments were elusive.

The next stage brought the focus down to shoreline segments (called reaches) where the erosion rate was 4 feet or more, or where other factors warranted further study, namely: 1) a high volume of fastland loss per linear foot, 2) nearby navigation channels subject to high shoaling rates, and 3) nearby existence of commercial, residential, public or military development. The application of these criteria reduced the study area to 136 shoreline sections containing 1,260 miles (490 in Maryland and 770 in Virginia).[9]

At this stage, maps and charts were no longer very useful because they were not detailed enough, and were often too old (most were based on information

The shoreline designated for final study includes 91 reaches containing 135 miles (94 in Maryland and 41 in Virginia). This 135 miles of shoreline contains the most critical areas of erosion worthy of study to make more detailed estimates of the benefits and cost of various protection strategies.

gathered 10 or more years before). There had been a good deal of new development along the shores of the Bay since the Corps completed its erosion survey in 1977, and a number of localities or individuals had constructed protection facilities that were not shown on any maps. For those reasons, an aerial reconnaissance was made of the entire Bay shoreline by the Baltimore and Norfolk districts. Slides and video tapes were made, flying directly above the shoreline and again at 500-1000 feet offshore.

After reviewing all the slides and tapes of the aerial reconnassiance, the Corps could apply even more stringent criteria for further consideration of the eroding shoreline reaches, a decision made necessary by the still poor cost-effectiveness of control strategies. In order to be considered further a shoreline reach would be required to exhibit at least one of the following characteristics: 1) erosion rate of more than 4 feet per year along a reach that was forested, farmed or had scattered residential land uses, 2) an erosion rate of more than 2 feet in areas of concentrated residential development (250 or less feet of shore frontage per property), 3) the existence of public roads, bridges or utilities, 4) adjacent navigation channels, 5) areas where shoreline protection facilities had obviously failed, 6) volumetric losses of materials greater than 2 cu. yd. per linear foot or losses greater than 1 cu. yd. per linear foot in areas where oyster, clam or SAV beds lay within 1,400 feet of the shore in less than 12 feet of water. Under this criteria, 120 reaches were identified, covering about 208 miles (120 miles in Maryland and 88 in Virginia).[10]

Having reduced the shoreline reaches still under consideration to 3.4% of the total portion of the Bay that was eroding, Corps officials met with staff members from the Maryland Department of Natural Resources and the Virginia Institute of Marine Science to discuss each reach and look at preliminary benefit/cost data for various types of protection facilities that could be developed. Next, a team from Baltimore went out to every reach to examine it more closely from the ground where that was possible. In some areas, erosion protection facilities were found that were not apparent from the aerial photos and tapes. On the basis of all this analysis, the shoreline designated for final study was delineated. It included 91 reaches containing 135 miles (94 miles in Maryland and 41 in Virginia). These ranged in length from a 6.6-mile reach of shoreline north of St. Jerome Point in St. Mary's County, Maryland to a 500-foot section of Solomons Island near the mouth of the Patuxent River.[11]

This 135 miles of shoreline contained the most critical areas of erosion the Corps believed worthy of study in order to make more detailed estimates of the benefits and cost of various protection strategies. These were not the only areas of the Bay with erosion problems that needed to be addressed. Clearly, hundreds of other miles of shoreline were eroding, but the problem was less critical, and the economic justification for their protection by the federal government was lacking. In fact, when the 91 reaches labelled "critical" were studied by the Corps' engineers and economic analysts, only 28 specific reaches, containing 23.6 miles of shoreline, had sufficiently high site-specific benefit-cost ratios to warrant a detailed feasibility study as a specific federal project.[12]

However, the analysis of the other 111.4 miles of critically eroding shoreline showed that the specific benefits from protecting each reach, when added to the cumulative benefits of fastland-generated sedimentation reduction from all 111.4 miles, obtained favorable benefit-cost ratios. The total annual contribution of sediments into the Bay from the erosion of all fastland was calculated to be approximately 4.7 million cu. yd. If the sedimentation from the eroding nearshore is added, the figures rise to 11 million cu. yd., but the cost and complexity of controlling this source argued against attempts to calculate benefit-cost figures for this area.

Also, the fastland sedimentation was itself a major factor in the Bay since the total sediment contribution of the Bay's rivers is approximately 4.3 million cu. yd., the fastland erosion alone contributes 52% of the total annual sedimentation![13] The benefits of reducing this sedimentation along the 135 miles of critically eroding shoreline would stem from developing

shoreline protection facilities that would prevent as much as 931,000 cu. yd. of sediment from entering the Bay each year. This is equal to approximately 20% of the 4.7 million cu. yd. of fastland sediment washed into the Bay annually along its entire shoreline. Adding in the 4.3 million cu. yd. delivered annually by the Bay's rivers, the reduction of sedimentation along the 135-mile critical erosion area would reduce total Bay sedimentation by 10%.[14]

This seemingly small reduction in sedimentation has substantial Bay-wide economic benefits for water-oriented recreation, reduced channel maintenance, and improved water quality with benefits for commercial fishing. In addition, it would have site-specific benefits through the reduction of land loss and the prevention of property damage to private and public structures and facilities. Benefits were quite substantial in cases such as maintenance dredging prevention. Here the reduction of sedimentation by 10% would bring an annual savings in maintenance dredging of $558,000. The benefits to the living resources of the Bay were even larger, amounting to an estimated $13.9 million per year.

When compared with various types and combinations of erosion prevention facilities (bulkheads, sea-

Many erosion prevention structures are used along the shores of the Chesapeake. The federal government actively assists the private sector in shoreline erosion control, and has done so since 1946.

walls, revetments, groin fields, breakwaters, breakwatersills, shore stabilization, vegetation plantings and vessel speed controls), the benefit-cost ratio was 1.35. A lower level of erosion protection that would hold back about 7.5% of the sediments instead of 10%, had a ratio of 1.75, so the greater level of benefit would come with the construction of an erosion protection system that would withstand a higher level of wave action. The costs were based on estimates of the original construction cost plus 50-year maintenance costs of erosion protection devices deemed most cost effective and environmentally sound for each erosion site.[15]

Colonel Walsh reviewed the Reconnaissance Report and recommended that the project be funded for the feasibility phase. He urged a threefold plan of action. First, the developmment of a comprehensive plan for all 135 miles of critically eroding shoreline. Second, detailed investigations at 22 specific sites (covering 18.6 miles), where a potential for a federal project existed. These would be in addition to the six sites (covering 5.0 miles) which were already moving forward towards construction under the Corps' continuing authorities program. Third, he recommended the installation and monitoring of several field modeling sites to determine the effectiveness of a variety of innovative low-cost erosion control strategies.[16]

Under current federal policy, the feasibility phase of the study required 50/50 cost sharing between the federal government and the states of Maryland and Virginia. The two states expressed their willingness to pay their share and urged the federal government to undertake the program. Funding was included in the Water Resources Development Act of 1986, and in April 1987, Assistant Secretary of the Army Dawson approved release of funds for the second and third of Colonel Walsh's recommendations. In May 1987, Maryland and Virginia signed agreements to fund their shares of the feasibility phase. Work began in late May. The Baltimore District undertook feasibility studies, including detailed engineering, environmental and economic studies, for 21 specific sites (an additional site had been funded through the continuing authority program). The field modeling program also began in May with the selection of 7 sites (4 in Maryland and 3 in Virginia). The Maryland projects are on the western side of Smith Island, Terrapin Beach on the east side of Kent Island, St. Mary's County Park just north of the Calvert Cliffs Nuclear Power Station, and an area of Elk Neck State Park at the southern tip of Elk Neck. In Virginia, the three projects are all in the vicinity of Hog Island State Park on the south bank of the James River. The cost of the feasibility stage of the study is $2,970,000 of which the federal government will pay half. Maryland and Virginia will pay $794,500 and 690,000 respectively.[17]

The Baltimore District Regulatory Program

The regulatory program of the Baltimore District is perhaps its most far reaching environmental protection activity. The number of applications received by the district for permits to alter shorelines, river banks or wetlands has increased annually. In the mid-1970s, about 1,500 permits per year were processed. By 1986, the number had risen to just under 3,000 and exceeded 4,000 in 1987. Permit applications range from those requesting to build a small private boat pier or to fill a few square yards of wetlands adjacent to a tiny stream, to projects such as the Hart-Miller Island disposal area, the recently proposed $100 million Baltimore International Yachting Center in Baltimore, or the gigantic billion-dollar Port America Project on the Potomac estuary.[18]

As indicated briefly in Chapter I, the Corps' regulatory activities are rooted in the River and Harbor Act of 1899. Section 10 of this act required all individuals, commercial enterprises or government agencies to obtain a permit from the Corps of Engineers before excavating or depositing materials, or placing any type of obstruction in the navigable waters of the United States.[19] The act also required, under Section 13, that a Corps permit be obtained for the discharge of "refuse" into navigable waters. Until 1968, this authority was used by the Corps only for the protection of navigation. Environmental impacts were not considered.

Between 1968 and 1972 this changed dramatically. First, Federal Court cases and the growth of environmental concern in the 1960s led the Corps to revise its Section 10 permit program in 1968, to consider the impact of permit applications on fish and wildlife values, conservation, pollution, aesthetics, ecology and other factors of general public interest. Public notices of all permit applications were sent to government agencies, private groups or individuals wishing to receive them so they could respond to the Corps with comments or objections. This new type of review called a "Public Interest Review" became standard procedure for all major permit decisions and is still the backbone of the Corps' decision making process.[20]

The next year NEPA was enacted by Congress. This meant thousands of environmental assessments had to be made for permit applications, even if they were quite small projects, as many were. The requirement to write environmental impact statements or assessments was not a complete shock to the Corps since its 1968 reform had led to the development of a procedure roughly similar to the EIS or environmental

assessment (EA) required under NEPA. The new regulations under NEPA called for the considerations of more factors.

The second major change concerned Section 13 of the 1899 act. In 1970, the House Committee on Government Operations, in pursuance of a Supreme Court decision rendered a decade before, discovered that Section 13 of the 1899 River and Harbor, the so-called "Refuse Act," could be applied to water pollution, and recommended the Corps use this section, through its permit program, to control industrial pollution. The Corps undertook such a program, but the 1899 Refuse Act was difficult to interpret. Its language was inconsistent with the more modern concept of pollution embodied in the Federal Water Pollution Control Act (FWPCA), which Congress had passed in 1968, but nevertheless the Supreme Court's view of the older statute placed thousands of industries in immediate violation of the law. The Corps began to hire personnel to enforce the new permit guidelines under the Refuse Act, but it was clear some adjustment in the program was necessary. The problem was resolved by the Federal Water Pollution Control Act Amendments of 1972.[21]

The Federal Water Pollution Control Act Amendments of 1972, commonly known as the Clean Water Act, is the landmark piece of legislation in the nation's effort to control water pollution and is, next to NEPA, the Corps' most important environmental protection authority. The objective of the act, as stated in its opening paragraph, is to ". . . restore and maintain the chemical, physical and biological integrity of the nation's waters."[22] The Corps retained its regulatory authority over all types of physical structures, dredging and filling in navigable waterways under Section 10 of the 1899 River and Harbor Act, but Sections 402 and 403 of the FWPC Act transferred the pollution control features of Section 13 of the old 1899 Refuse Act to the Environmental Protection Agency. The EPA now regulated the disposal of industrial and chemical wastes, sewage, non-point pollutants and other such effluents into the navigable waters of the United States.

EPA has established detailed guidelines and delegated their implementation to the state governments. Section 404, established in the 1972 FWPCA Amendments, gave the Corps of Engineers permitting authority over the disposal of all dredged or fill materials in the navigable waters of the United States, making it clear that the goal in this section was the water quality of the aquatic environment. Under Section 404(b)(1), the Corps cooperates with EPA in developing and implementing the water quality and environmental guidelines contained in this section. Pursuant to Section 404(c) of the FWP Amendments of 1972, EPA may veto Corps permit decisions. This has very seldom occurred because the Baltimore District of the Corps has become a well-known protector of the aquatic environment under its Section 10 and Section 404 programs. One legal scholar, reviewing the development of the Corps' permit program between 1972 and 1978, concluded that the agency had indeed become a strong advocate of environmental protection on the nation's coastal and inland aquatic environments. "Once the nemesis of environmentalists," he said, "the Corps is now its hero."[23]

Of almost equal importance to the enactment of Section 404 was the expansion of its coverage. In 1972, the Corps interpreted the territorial coverage of Section 10 and Section 404 to be synonymous and as such to include the traditionally navigable waterways of the United States and their adjacent wetlands. However, on 27 March 1975, the U.S. District Court for the District of Columbia in *Natural Resources Defense Council, Inc. v.* [Sec. of the Army] *Callaway* ordered the Corps to amend its regulations to extend its 404 authority from the navigable water to "all waters of the United States."[24] This decision brought every brook, creek, and stream, and all their adjacent wetlands under Section 404, while upholding the Corps' Section 10 and 404 jurisdiction over traditionally navigable waters. Two years later Congress incorporated the principle laid down by the Federal Courts in the *Callaway* decision into law. The 1977 amendments to the 1972 Federal Water Pollution Control Act, commonly called the Clean Water Act of 1977 (PL 95-217, 27 December 1977) confirmed in law the expansion of Corps authority into all streams and their adjacent wetlands.

The major legal challenge to this expansion of Corps authority was the *Riverside Bayview Homes Case*, which was decided, on appeal, by the U.S. Supreme Court on 4 December 1985. The court confirmed the 1975 definition of wetlands as all areas having sufficiently saturated soil from surface or ground water to support wetlands vegetation. It also confirmed that protection of wetlands was a legitimate exercise of authority under Section 404 due to the intimate role these areas play in the total aquatic system of the nation's watersheds. It was an important victory to the Corps and its regulatory program.[25]

The Corps "404 program" as it is commonly called, has developed into what one of the EPA's top officials has called "the most important federal regulatory program for the protection of wetlands."[26] No one can undertake any dredging, filling or construction that involves the discharge of dredged or fill materials into any body of water or into any wetland in the United

States without a permit from the Corps. As always, the challenge to the Corps in administering this vast program is to balance a variety of interests and values according to the guidelines of NEPA and the Clean Water Act. General Hatch, writing in the *EPA Journal*, explained it in the followng terms:

The role of the Army Corps of Engineers in administering Section 404 . . . is to decide which of the many competing interests for the use of waters of the United States are not contrary to the public interest. Accordingly, we are reluctant to make emphatic statements on what Section 404 is or is not in terms of wetland protection. Emphatic statements (in either direction) would

create a "blanket" approach in evaluating some of our most troublesome permit applications, namely, those involving fill in wetlands. . . . when evaluating an application for a project in a wetland, we should first determine to the extent possible what functions the wetland performs; the values of those functions to the public; and how that project would affect those values.[27]

Section 404 helps local governments and private parties to redesign their projects in a way that will limit damage to the local aquatic environment.

The Baltimore District, encompassing all the Chesapeake Bay shoreline and wetlands plus all the Bay's rivers and their wetlands in Maryland, has a very large responsibility under Section 404. Among the 39 Corps districts, Baltimore is one of the five busiest in terms of the volume of applications. It is also well above the national average for the Corps in the number of permit applications modified by negotiation, to ensure that reasonable development proceeds in an environmentally sensitive manner.

Modification of dredge or fill projects is the key to success. The purpose of Section 404 was not to end all further development along shorelines and wetlands, but to help local governments and private parties to redesign their projects in a way that will limit damage to the local aquatic environment. In a number of cases, this means decreasing the size and altering the configuration of projects. In a few cases, where projects will be quite destructive of wetlands without very compelling social or economic benefits, permits are simply denied. This is rare. The more usual result of Corps opposition is the withdrawal of the application before a denial is issued. This occurs with about 10% of the applications submitted.[28]

Seldom does the Baltimore District have to take legal action to halt a project. Early successes by its enforcement officials (acting in conjunction with the Department of Justice) in Federal Court, set the tone for the overall success of the regulatory program in the district. In 1974, the district was one of the first in the country to file suit against violators of the Section 404 discharge prohibition. The case, involving the discharge of dredged material into a wetland by a private contractor in Worcester County, Maryland, was an important judicial decision. Developers found the courts backed the Corps. This laid the basis for direct negotiations between private permit applicants and the local regulatory officials from the Baltimore District office to redraft unacceptable shoreline or wetland construction plans to lessen ecological damage and in many cases actually enhanced the local aquatic environment.

The effectiveness of the Baltimore District's regulatory program depends heavily on the abilities of its regulators. The district's regulatory personnel have

grown up with the 404 program and its immediate predecessors. The chief of Operations Division, in which the Regulatory Branch is located, is John P. O'Hagan, whose many years of experience with the district and the problems of the Bay area have made him a key supporter of the regulatory program. The program had to be completely restructured after the 1968-1972 changes. O'Hagan had the foresight in the mid-1970s to realize the need for both engineers, as well as natural scientists to work in the Regulatory Branch. In 1978, he hired Donald Roeseke, a talented engineer, who had previously established the district's Environmental Branch to lead the Regulatory Branch. Working with the head of the Regulatory Branch's Enforcement Chief, Robert Edwards, Roeseke brought in a number of young chemists, biologists and ecologists who form the backbone of the permit program. The first were hired in 1974, and there are now 32 professionals in the program. This is, in spite of its size, a relatively small staff to handle the tremendous volume of work entailed in reviewing an average of 240-300 permits per month, which average in excess of $25 million worth of construction each month.

Some of this burden has been eased by the development of the Nationwide Permit Program. This allows up to 26 types of simple, small-scale projects that have only minor impacts on the local environment (and are not in conflict with any state or local regulatory laws) to receive automatic approval if they meet general guidelines established by the Office of the Chief of Engineers. Personnel from the Baltimore District, recognized for their expert knowledge of permit issues, were called to Washington on several occasions to assist with the establishment of permit guidelines and to help with the development of the Nationwide Permit Guidelines.

In the same vein as the Nationwide Permit system, the district has developed its own "blanket permits," legally referred to as Regional General Permits, for activities which, once agreed upon, do not generally require continuous assessment through the permit program. One of the first uses of a blanket permit is the Eastern Shore mosquito ditch program. In order to control mosquitoes in the wetlands of the Eastern Shore, the Maryland Department of Agriculture has for many years dug "mosquito ditches" through local wetlands to allow fish to eat the mosquito larva. But dredged material from the ditches often disrupted the flow of water in the wetlands and altered its ecology. The problem came to the Baltimore District Regulatory Branch because each ditch resulted in wetlands filling and thus required a 404 permit. To find a solution, the Corps formed a task force composed of representatives from the district office, Maryland's agriculture and natural resources agencies, EPA, Fish and Wildlife, National Marine Fisheries, and the Soil Conservation Service. A new method of ditching was found that sprayed the dredged material in a thin layer over the adjacent area rather than depositing it right along the ditch to form a raised berm.

In addition, this interagency task force adopted the concept of Open Water Marsh Management for Maryland's tidal wetland and instructed ditchers on the use of OWMM techniques to minimize wetland drainage/damage and maximize mosquito control. Tests showed these practices have no significant adverse effect on the ecology or hydrology of the wetland and are now ingrained into the methodology for mosquito control. Each year blanket permits are issued to the Maryland Department of Agriculture for all the hundreds of miles of mosquito ditches it will dig during the season. The work is monitored by a Mosquito Steering Committee composed of officials from the federal and state agencies who helped devise the original program.[29]

The blanket permits and nationwide permits have been helpful, but there are also many larger projects involving 10, 50, or even 100 acres of land and the movement of thousands of tons of material that require far more study. The Regulatory Branch assigns a team of experts to these applications, sometimes calling in additional personnel from the Environmental Branch. The Permit Branch hired a wide range of expert biologists, chemists and ecologists who have specialized in particular types of aquatic problems. In addition, the district meets regularly with officials from EPA, Fish and Wildlife, National Marine Fisheries, and other federal agencies. Through its Public Review System, environmental groups, local community organizations and individuals can also express their views and make suggestions. The acutal review process involves the assessment of the project from a very wide list of perspectives. Both the beneficial and harmful impacts of the project are examined and it is placed in the context of the larger scale changes occurring in the area. The last factor, the cumulative effect of a large number of small projects, is also considered. The types of factors considered by the Baltimore District, as stated on its permit applications are as follows:

> The decision whether to issue a permit will be based on an evaluation of the probable impact including cumulative impacts of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefit which reasonably may be expected to

accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, food hazards, flood plain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food production, and, in general, the needs and welfare of the people.[30]

Clearly, it is not possible to provide precise or quantitative weights to the various benefits and drawbacks of most projects, especially for larger more complicated activities. As a general rule, however, the Baltimore District is very reluctant to allow the destruction of any substantial amount of wetlands.[31] Even the filling of relatively small amounts of wetlands are compensated by "mitigation," the construction of new wetlands or natural habitats to compensate for the loss of existing ones.

In Baltimore Harbor the loss of wetlands for the construction of the Fort McHenry Tunnel by the Maryland Department of Transportation was mitigated by MDT's agreement to construct three new wetland areas within the harbor. This was the condition under which the Corps granted a permit for the tunnel. The result was a net increase in the amount of wetlands area of the harbor for the first time in its history. An analysis of all such permit decisions by the Baltimore District for the 1983-1985 period showed that the district issued permits allowing 19.1 acres of wetlands to be filled, while requiring the creation of 80 new acres of wetlands by permit applicants.[32]

This record of achievement led the president of the Chesapeake Bay Foundation to tell the House Subcommittee on Fisheries and Wildlife Conservation and the Environment on 20 May 1987 that he wished to commend Colonel Walsh and the Baltimore District, "for the excellent job he has done" in protecting wetlands in the district's portion of the Chesapeake Bay watershed.[33]

The shoreline and wetlands of the Chesapeake Bay are clearly a critical area for the ecological health of the entire estuary. The Corps of Engineers has been given a large responsibility in determining the ways in which these areas will be treated by owners and users. The shoreline erosion program seeks to control a serious natural hazard in ways that are both environmentally sound and economically realistic. Its shoreline and wetlands regulatory program places the Corps in the position of making Solomon-like decisions over development plans that sometimes run into hundreds of millions of dollars. Together, the erosion and permit programs provide the major administrative structures that will determine the future of the Chesapeake's most endangered environmental areas. Since the early 1970s, the Baltimore District has built an experienced staff of environmental and engineering experts, who have managed to preserve and enhance the shoreline environment in ways that win the approval of environmentalists without stifling shoreline development.

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